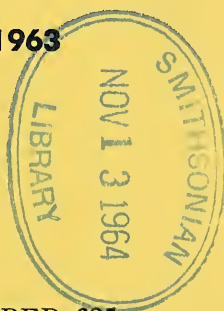


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Annual Report
of the
New York State Museum
and Science Service

July 1, 1962 - June 30, 1963



MUSEUM BULLETIN NUMBER 395

NEW YORK STATE MUSEUM AND SCIENCE SERVICE

ALBANY, NEW YORK

*The University
of the State
of New York*

*The State
Education
Department*



1964

125th Annual Report of the New York State Museum and Science Service

*The University
of the State
of New York*

ALBANY, NEW YORK

*The State
Education
Department*



1964

The University of the State of New York

Regents of the University

terms expire

EDGAR W. COUPER, A.B., LL.D., L.H.D., <i>Chancellor</i> , Binghamton	1968
THAD L. COLLUM, C.E., <i>Vice-Chancellor</i> , Syracuse	1967
ALEXANDER J. ALLAN, JR., LL.D., LITT.D., Troy	1978
GEORGE L. HUBBELL, JR., A.B., LL.B., LL.D., LITT.D., Garden City	1966
CHARLES W. MILLARD, JR., A.B., Buffalo	1973
EVERETT J. PENNY, B.C.S., D.C.S., White Plains	1970
CARL H. PFORZHEIMER, JR., A.B., M.B.A., D.C.S., Purchase	1972
EDWARD M. M. WARBURG, B.S., L.H.D., New York	1975
J. CARLTON CORWITH, B.S., Water Mill	1971
JOSEPH W. MCGOVERN, A.B., LL.B., L.H.D., LL.D., New York	1969
ALLEN D. MARSHALL, A.B., LL.D., Scotia	1965
JOSEPH T. KING, A.B., LL.B., Queens	1977
JOSEPH C. INDELICATO, M.D., Brooklyn	1974
MRS. HELEN B. POWER, A.B., Rochester	1976

JAMES E. ALLEN, JR. President of the University
and Commissioner of Education

EWALD B. NYQUIST Deputy Commissioner of Education

HUGH M. FLICK Associate Commissioner for
Cultural Education and Special Services

WILLIAM N. FENTON Assistant Commissioner for
State Museum and Science Service

VICTOR H. CAHALANE Assistant Director of State Museum

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Museum Advisory Council

1963	W. STORRS COLE,	Utica Ithaca
1964	FREDERICK J. DOCKSTADER,	New York City
1965	WILLIAM C. STEERE,	New York City
1966	GEORGE F. GOODYEAR,	Buffalo
1967	CHESTER M. SUTER,	Chatham

The Staff

State Museum and Science Service

WILLIAM N. FENTON

Assistant Commissioner

Anthropological Survey

WILLIAM A. RITCHIE

State Archeologist, Associate Scientist

ROBERT E. FUNK

Junior Scientist

Biological Survey

DONALD L. COLLINS

State Entomologist, Principal Scientist

DONALD P. CONNOLA

Senior Scientist (Entomology)

PAUL F. CONNOR

Scientist (Zoology)

RODNEY C. DEGROOT

Senior Scientist (Botony)

HUGO A. JAMNBACK, JR.

Senior Scientist (Entomology)

DONALD M. LEWIS

Junior Scientist

EUGENE C. OGDEN

State Botanist, Associate Scientist

RALPH S. PALMER

State Zoologist, Associate Scientist

Geological Survey

JOHN G. BROUGHTON

State Geologist, Principal Scientist

JAMES F. DAVIS

Scientist (Geology)

DONALD W. FISHER

State Paleontologist, Associate Scientist

Y. WILLIAM ISACHSEN

Associate Scientist (Geology)

W. LYNN KREIDLER

Senior Scientist (Geology)

LAWRENCE V. RICKARD

Senior Scientist (Paleontology)

ROSS P. SANGSTER

Science Research Aide — Wellsville Office

ARTHUR M. VAN TYNE

Scientist (Geology) — Wellsville Office

VACANT

Senior Scientist (Geochemistry)

State Museum

VICTOR H. CAHALANE

Assistant Director

Curatorial

ROGER L. BORST

Associate Curator (Geology)

JENNIFER CHATFIELD

Associate Curator (Interpretation)

CHARLES E. GILLETTE

Associate Curator (Archeology)

CLINTON F. KILFOYLE

Associate Curator (Paleontology)

EDGAR M. REILLY, JR.

Associate Curator (Zoology)

STANLEY J. SMITH

Associate Curator (Botany)

JOHN A. WILCOX

Associate Curator (Entomology)

Exhibits

HELEN C. FISHER	Museum Technician (NDEA)
EDITH FROELICH	Museum Technician (Temporary)
LEWIS E. KOHLER	Museum Technician
LOUIS J. KOSTER	Senior Museum Technician
HAROLD W. ROSS	Museum Technician (NDEA)
ROBIN D. ROTHMAN	Museum Technician
THEODORE P. WEYHE	Museum Exhibits Designer

School Services

C. MICHAEL DARCY	Museum Instructor (NDEA)
JUDITH A. DRUMM	Museum Instructor
MARY JANE STAUCH	Museum Instructor (Temporary)
JANET L. STONE	Museum Education Supervisor

Library

EILEEN COULSTON	Librarian, Junior Scientist
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Clerical

MARION B. BENDER	Clerk
MARYELLEN CANFORA	Typist
LINDA A. HEERAN	Stenographer (NDEA)
JOAN C. KELLEY	Senior Stenographer
JOSEPH T. KILLEA	Mail and Supply Helper
ROSELLE LITHGOW	Clerk
VERA MCMILLEN	Senior Stenographer
PATRICIA SARGOOD	Stenographer
MARJORIE R. SCHMIDT	Principal Clerk
CATHERINE M. STAPLETON	Stenographer
MARY C. STEARNS	Stenographer
EILEEN A. WOOD	Senior Stenographer

Guards

JOHN C. CUNNINGHAM	Building Guard
ANTHONY GENSICKI	Building Guard
EDWARD W. MC CARTY	Building Guard
WILLIAM C. ZIMMER	Museum Caretaker

Photographer

JOHN A. HELLER	Museum Photographer
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Maintenance

JACOB SMALLENBROEK	Carpenter
JAMES WIEDEMANN	Maintenance Man (Carpenter)

General Statement

I have the honor to return a report on the activities and accomplishments of the New York State Museum and Science Service for the year ended June 30, 1963.

Following a presentation to the Regents of the *Report of the Commissioner's Committee on Museum Resources*, a document which was to appear during the year in printed form and to attract wide attention, the writer flew to Holland to attend the International Council of Museums (ICOM '62), to study old collections from America in the museums of northern Europe, and to attend the meeting of the Permanent Council of the International Congress of Anthropological and Ethnological Sciences held in Prague, Czechoslovakia, during the first week in August. European travel for these purposes was entirely supported by grants from outside agencies, and no State funds were involved.¹

The opportunity to attend the ICOM '62 meeting at The Hague, the Netherlands from the 2d to the 11th of July enabled the writer to see the outstanding Dutch collections in art, science, natural history, ethnography, and the folk arts; to study techniques of presentation and other aspects of museology; and especially to meet colleagues from the principal museums of Europe. At Leiden, he was able to fulfill a personal research interest to examine and photograph old ethnographic specimens from the New World, beginning with a war club and a wampum belt from New Amsterdam, a pursuit that was to lead across nine countries during the summer with gratifying success. He was diverted from this trial briefly in early August by going to Prague to join the U.S. Committee on the Permanent Council of the International Congress of Anthropological and Ethnological Sciences (ICAES), which met at the Czech Academy of Sciences on the invitation of the Soviet Academy to review plans for the Moscow Congress of 1964.

ICOM '62 was beautifully organized and run with precision by the Dutch Committee. An enormous effort went into the planning. It

¹ Expenses at ICOM were, in part, supported by the American Council of Learned Societies; the study of museum collections was made possible by an anonymous gift to the Regents; travel to and from Europe was underwritten by the Social Science Research Council.

may be useful here to comment on structure and procedure because the next conference will be held in New York City in 1965, and a thorough understanding of what such an international gathering involves is vital to its success. Formal sessions of general and specialized interest alternated with workshops. Perhaps the most valuable feature of the meetings was the excursions to outdoor museums, to cultural centers and the great galleries, notably Delft, Utrecht, Amsterdam, Arnhem, Rotterdam, and Haarlem. The appreciation of the arts in high places from Queen to Burgomaster strikes the museum director from America as something to be emulated. The American Committee for ICOM will have difficulty approaching the level of Dutch official support. Ways and means will have to be found for accomplishing these amenities from public and private sources.

Both from the viewpoint of personal research on surviving collections illustrating the arts and industries of the Northeastern Indians and of museology (the care and preservation of collections, their display, museum architecture, and administration), the visit to museums was most rewarding. The nine countries comprised the Netherlands, Denmark, Norway, Sweden, Germany, Austria, Czechoslovakia, Switzerland, and France. Of museums visited, there were 4 open-air folk museums, 19 ethnological museums, 3 private collections, and 2 art museums specifically having old collections in the area of interest. More than 200 colored photographs of specimens and museum interiors were made and information on individual specimens was recorded from the old catalogs wherever available. It would be difficult to exaggerate the hospitality accorded by colleagues in their home institutions. The author was frequently given the keys and allowed to return at will on weekends to study and photograph specimens. An amazing number of old New York Indian specimens was actually located, and some specimens of more recent vintage served to document collections in the State Museum. He was frequently able to identify specimens that were simply marked North America in the catalog.

Returning to Albany in mid-August, there was barely a month to put the finishing touches on a fur trade exhibit and welcome the American Indian Ethnohistoric Conference to Albany on Columbus Day weekend. The occasion also marked the 15th Conference on Iroquois Research. The State Museum, the State Library, and the Division of Archives and History jointly sponsored the meetings which were held in the State Museum and in Henry Hall. The second session (in Henry Hall) was opened by the Mayor of Albany, the Hon. Erastus Corning II. A field trip to the site of Gandaouaga

Castle, Fonda, N.Y., and to Johnson Hall opened the eyes of our scholarly visitors to the opportunities and sites for ethnohistorical study in New York State.

Legislation implementing the "Hochschild Report," as the *Report of the Commissioner's Committee on Museum Resources* has come to be known, was introduced in the 1963 Legislature. For the first time, the author was involved in answering repeated queries about the nature of the program and the implications of the bill. The bill survived until the last day of the session, when it was recommitted until another year.

Other notable events, as submitted in quarterly reports to the Governor, included:

Investigation of the feasibility of the protection of cultural objects in museums of New York State during nuclear attack by storage in salt mines. Research was conducted by James F. Davis, of the Geological Survey, at the request of a committee appointed by Commissioner Allen, headed by James J. Rorimer, Director, Metropolitan Museum of Art. Results were well in hand at the end of the year.

Progress was made toward the completion of Paleontology Hall. With the signing by the Governor of the new oil and gas statute, the Geological Survey assumed new responsibilities and will serve as a prime consultant to the State Conservation Department on all matters of oil and gas drilling and gas storage in New York State.

The Curator of Geology cooperated with the State Department of Labor in a study of talcosis, a lung disease caused by the inhalation of needlelike mineral particles.

Sunday openings of the State Museum were shifted from summer to spring, resulting in an increase in the average daily attendance from 230 to 570 per Sunday.

Other areas of this report bespeak scientific progress on several fronts; attention is called to the increased use of our educational services by school groups coming to the Museum to supplement offerings of the regular curriculum. Distinct progress is noted in all areas toward the recognition of the museum as an instrument of education.

STAFF CHANGES

On June 13 and 27, respectively, Rodney C. DeGroot received provisional appointment as Senior Scientist (Botany) and Jennifer Chatfield as Associate Curator (Interpretation). Helen C. Fisher and Harold W. Ross were appointed as Museum Technicians on August 9 (Title III — NDEA). Joan C. Kelley's position as Stenographer was reclassified to Senior Stenographer on February 7. On September 6, Patricia Sargood was appointed Stenographer upon the resignation of Margaret Bassotti. On the same date, Catherine M. Stapleton was appointed to the newly created position of Stenographer in the Anthropological Survey and Linda A. Heeran became Stenographer, under Title III — NDEA, for the Museum Education office. The guard staff lost a valuable employee in the sudden death of Alvin N. Turner on November 2, who was replaced by Anthony Gensicki on January 24.

WILLIAM N. FENTON

*Assistant Commissioner for
State Museum and Science
Service*

Accomplishments of the Surveys

ANTHROPOLOGICAL SURVEY

Excavations at the O'Neil site near Weedsport, Cayuga County, begun the previous summer, were completed. The site's importance was enhanced by the discovery of a new transitional culture, the Frost Island phase (1250 B.C.).

Subsidized by the National Science Foundation, the study of settlement patterns was continued at a site in Schuyler County. Burials were excavated at Isle La Motte, Vt., and site reconnaissance was conducted at Martha's Vineyard, Mass., in the Hudson Valley, and in central New York.

With student assistance, work continued at the prehistoric Mohawk Iroquois village site of Garoga in the Mohawk Valley.

In addition, a basic plan for a statewide highway salvage program was projected in a series of conferences with officials of the New York State Department of Public Works.

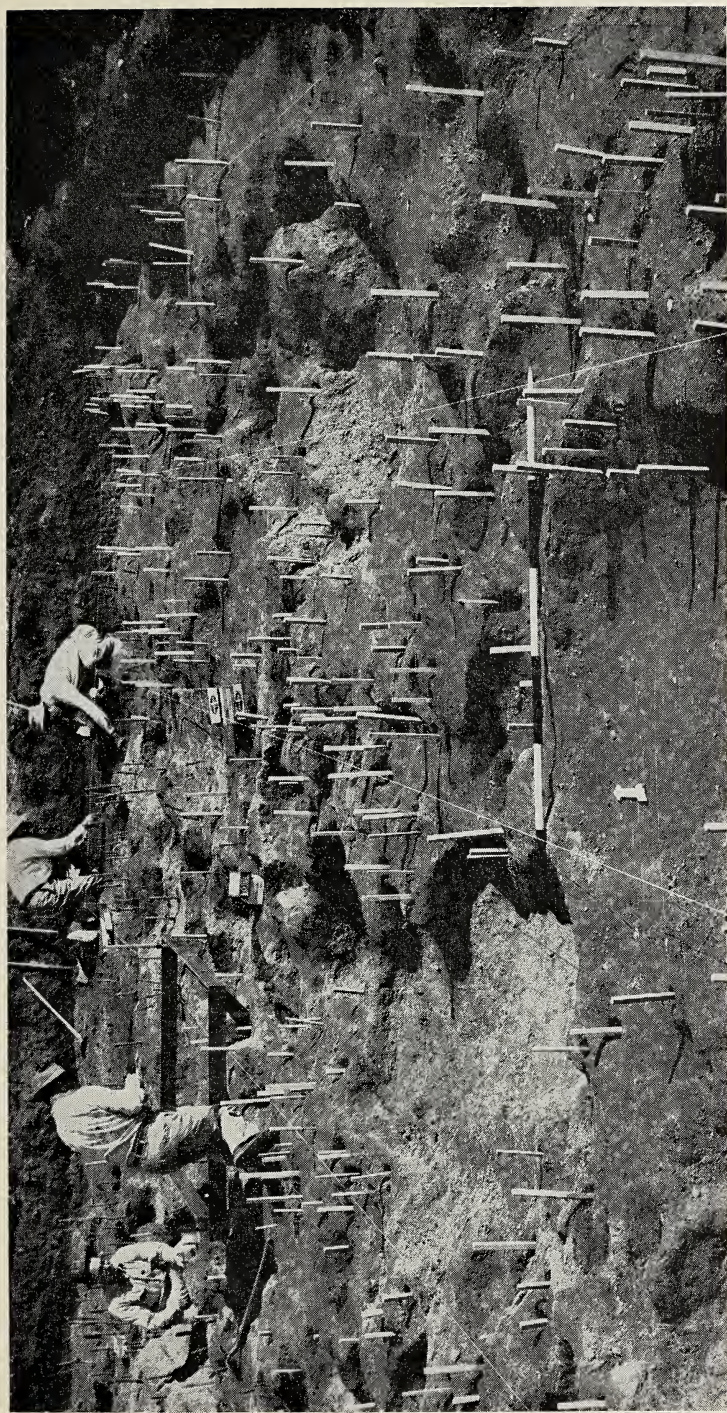
Collections and data from sites excavated in 1962 were mapped, analyzed, and written up for publication; all photographs and Kodachrome slides were organized and captioned.

BIOLOGICAL SURVEY

Among the activities of the Biological Survey during the period were the three papers by Dr. Robert W. Campbell which describe some of the principal finds of a 5-year study of gypsy moth ecology and biology; the discovery of a hitherto unknown virus in mosquitoes; and the recommendation of Dr. Ogden's roto-slide pollen sampler as the standard sampler for the American Institute of Allergy. The *Handbook of North American Birds*, published toward the end of the previous report period, has sold more than 3,000 copies during the past year, and has been acclaimed as "the finest handbook in the world" and "one of the major ornithological publications of our times," as stated in scientific journals.

Using techniques and apparatus perfected during the past several years, about 17,000 samples of ragweed and timothy pollen were collected. A 130-foot tower was installed in a forest near Raquette

Lake for pollen sampling under those conditions. The preparation of drawings from the material in the aquatic plant studies is now underway.



Exploration of the Lamoka Lake site in Schuyler County continued into the present year. Radiocarbon dating has revealed that it is the oldest settlement yet known in New York State, about 3,000 B.C.



Changes in vegetation since the Ice Age are determined by collecting samples from lake sediments. The ice is a sturdier raft than a boat for obtaining fossil pollen and diatoms. Work under way at Mohonk Lake, Ulster County.

Field Research by Projects

BOTANY

Checklist of the grasses of New York State: In the course of exploring and collecting for vascular plants in general (see next project), 85 specimens representing 71 numbers were collected by the Curator of Botany. Common species were recorded on all trips and detailed observations on critical complexes in the genera, *Festuca* and *Agrostis*, were continued. Two new native subspecies were added to the list of grasses for the State; a possible new and undescribed taxon of *Calamagrostis* was discovered in the Catskills; one species, not seen in the State since the type was collected over 100 years ago, was found in a new station.

General survey of the vascular flora of New York State: Special trips were made to the Adirondacks, the Catskills, and Long Island. Specimens were collected and sight-records made in the following counties: Albany, Bronx, Columbia, Dutchess, Essex, Franklin, Fulton, Greene, Hamilton, Herkimer, Oneida, Rensselaer, St. Lawrence, Saratoga, Schenectady, Suffolk, Schoharie, Warren, and Washington. The curator was assisted in the field for several weeks by Norton G. Miller.

ENTOMOLOGY

Biological control of the gypsy moth by *Bacillus thuringiensis* was the subject of a continuing study. Further ecological studies in the permanent study plots and tests of pre-hatch chemical treatments were also made. Studies on white pine weevil, pine shoot moth, beech scale, and red pine scale were continued, and a special project was made of studying the insects affecting white ash. The collection of specimens and notes on *Culicoides* became extensive enough so that work on a bulletin on the *Culicoides* of New York was begun. Scuba diving to recover lake-bottom fauna for DDT analysis was an interesting activity undertaken by Dr. Jamnback after he had noticed erratic behavior among crayfish on the bottom of Blue Mountain Lake. DDT was recovered from several types of aquatic fauna. The unidentified virus recovered the previous year from mosquitoes and an ovenbird on Long Island was recovered again from the mosquito *Culiseta melanura*.

The Curator of Entomology conducted research on the identification and classification of the leaf beetles (Chrysomelidae). This work is a continuation of the project described in a previous annual report.

ZOOLOGY

The small mammal survey was continued on Long Island, and 265 specimens, including 20 species, were collected. Other continuing work included experiments by the Curator of Zoology on woodpecker repellents. Damage to buildings still occurs and as yet no safe repellent has been developed. Slight damage (one or two spots only) is caused by "courtship drumming" and is easily controlled by eliminating sounding board or by covering with soft sound-absorbing material. Extensive damage may result from feeding activities; some insect repellents reduce this by barring cluster flies and other insects from under shingles and crevices. Variable damage occurs through nesting-hole drilling or "bill-sharpening" activities and is not easily or cheaply controlled as some chemicals are harmful to woodpeckers or mar appearance of homes.

GEOLOGICAL SURVEY

The past year has been one of significant accomplishment in research and service by the Geological Survey.

A major milestone was the publication in December 1962 of the new State Geologic Map (up-to-date as of 1961). It was released as an atlas of five map sheets plus a 40,000-word illustrated text and, for those interested in limited areas, as five separate map sheets (Niagara, Finger Lakes, Adirondack, Hudson-Mohawk, and Lower Hudson). Other important publications were two correlation charts by Donald W. Fisher, State Paleontologist. They described the stratigraphic relationships of Cambrian and Ordovician rocks, respectively, in New York State. An innovation was *The Empire State Geogram*, a newsletter which is published three times per year. James F. Davis, the editor, has guided its contents so that it may be of interest not only to professional geologists, but also to mineral producers, teachers, and anyone interested in the earth sciences in the State. The winter issue is essentially a continuation of the annual research newsletter, which is now in its 13th year of service to the profession.

This spring, after five years of effort by the State Geologic Survey, the 1963 Legislature passed a comprehensive oil and gas conservation bill. Numerous meetings and conferences had been held during 1962 in order to iron out minor details in the final draft. Since

that time, activities have been directed toward guidance of the New York State Conservation Department in setting up a Division of Oil and Gas, to which the Geological Survey will act as consultant.

Other projects of note were :

Geological and geophysical exploration of the Western New York Nuclear Service site and other work in connection with storage of radioactive wastes and the location of a high flux test reactor site was completed by John G. Broughton.

A Department Professional Development leave was granted to Donald W. Fisher for the period from September 15, 1962, to September 15, 1963, for the purpose of compiling and writing a text on paleoecology. The sabbatical year was spent in research and writing.

Preparation of text and illustrations for a chapter on " Precambrian Geology of Northeastern United States " was continued by Y. William Isachsen. The account will appear in a forthcoming series of volumes by specialists on " The Precambrian."

The well cutting library was rearranged by W. Lynn Kreidler so that all samples of deep (sub-Trenton) wells are stored in Albany, and all those from shallow wells are stored in the Wellsville office.

Drafting and final assembly of a correlation chart on Devonian rocks of New York was completed by Lawrence V. Rickard.

An expansion of office and laboratory space for the oil and gas office in Wellsville was planned by Arthur M. Van Tyne. Departmental and Division of the Budget approval of this expansion has been given; the space will be occupied beginning July 1, 1963. It will permit increased and more efficient activities.

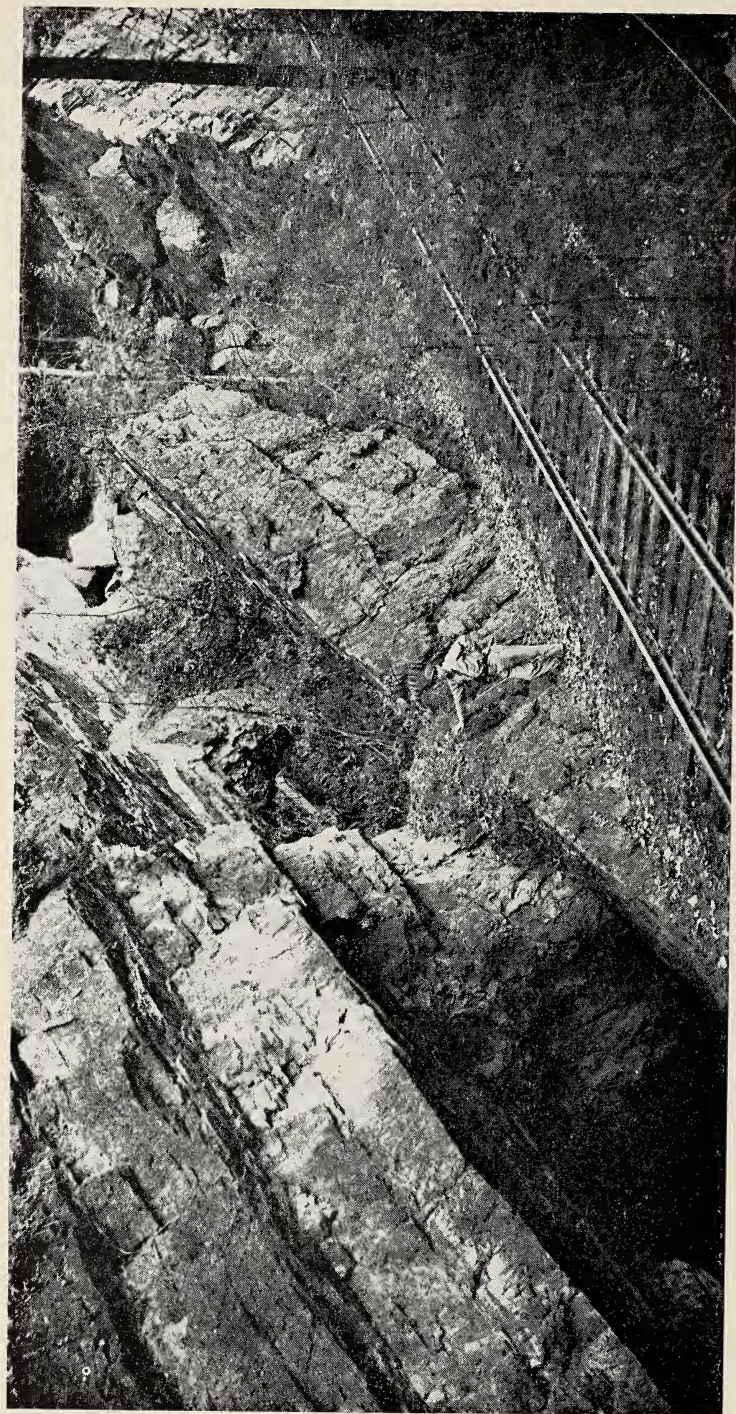
A survey of the International Salt Company mine at Retsof, as a possible long-term storage area for cultural objects, was completed by James F. Davis. The work required examination of all physical parameters that would affect the safe preservation of the objects.

During the report year, the position of Senior Scientist (Geochemistry) was approved. Because of current budget restrictions, the position was temporarily frozen but recruitment was carried on (so far, unsuccessfully). Full-time use of the chemical, X ray, and spectrographic laboratories awaits the filling of this position.

Detailed future planning for Geological Survey activity, although completed and in a standby condition, must await administrative approval and financing.

FIELD RESEARCH:

Completion of the geologic map of the State in 1961 and report editing, writing of research reports, and Dr. Fisher's leave for profes-



Geological field work in highly folded Silurian and Devonian rocks of the Helderbergian age near Rosendale. The opening (lower left) is that of an early 20th century cement mine, which is now converted to growing mushrooms.

sional development have combined to keep new field research of permanent staff members at a comparatively low level so that most in-state travel has been short term and of a supervisory or advisory nature.

In Dr. Fisher's absence, C. W. Flagler, formerly of the Gulf Oil Corporation, was employed as a temporary geologist to make subsurface correlations of the Cambro-Ordovician stratigraphy between the base of the Trenton Black River limestones and the Precambrian basement.

LABORATORY WORK:

Dr. Rickard spent a considerable amount of time during the past year in perfecting the adjustments and operation of the Stallwood jet assembly, an accessory of the Jarrell-Ash Emission Spectrograph. Progress was made toward the establishment of a semiquantitative procedure for approximately 35 elements using a powder standard and artificial silicate matrix. He also investigated a number of laboratory techniques in rock disaggregation as a beginning step in the study of Silurian and Lower and Middle Devonian conodonts from New York rock formations. The ultimate goal is to obtain better intercontinental correlations with Silurian and Devonian rocks in Europe.

The Curator of Geology, Roger Borst, continued his study of the clay minerals present in the Lower Devonian rocks of the central Hudson Valley. A rare chlorite mineral was discovered and is being subjected to intensive investigation.

For the past two years, the State Geological Survey has given partial support to research in geochronology by Dr. Donald Miller, of Rensselaer Polytechnic Institute. During 1962, Dr. Miller was engaged in setting up and standardizing his mass spectrometer; he now is making determinations of rubidium-strontium ratios in order to date micas and whole rocks in a number of Adirondack localities.

In the Wellsville office, a considerable increment was made to our record files through the activities of Mr. Van Tyne, aided by a part-time employee of the Bradley Producing Corporation, Judianne Gambrell. As a result of this work, data on 92 wells were added to our files from the H. Howard Cranston records which were turned over to us in the previous report year. Information on an additional 200-250 wells was brought to light, but the specific locations have not as yet been adequately checked. Additions of data were also made to the existing file records from this same source. The Bradley Producing Corporation, Wellsville, paid for the full cost of the record

transfer. A collection of oils, refinery products, geological specimens, well cuttings, and core samples was labeled and put on display in the Wellsville office for the information of visitors.

During the past year, more than 65,000 feet of well cutting samples totaling 7,300 samples were collected, cut, and stored by Messrs. Van Tyne and Sangster.

Mr. Davis made a survey of the production techniques and capacity of the lightweight aggregate industry in New York State, and the data was published in an issue of *The Empire State Geogram*. He completed a report on the mineral industry of Clinton, Essex, Franklin, Warren, and Washington Counties for the Mineral Resources Subcommittee of the New York-Vermont Interstate Commission on the Lake Champlain Basin and completed a resource map of the potential mineral deposits for the same area. This map is to be used by the Commission in a study of the possible competition for land which will be needed for diverse economic purposes.

Dr. Rickard spent much time in consultation with exhibit designers and preparators working on Ordovician and Devonian dioramas. He also made a special trip to Buffalo to assess the M. Kulp fossil collection and make recommendations for its purchase by the State Museum.

Much geological research has been summarized in completed manuscripts which now await publication.

The Museum

GENERAL

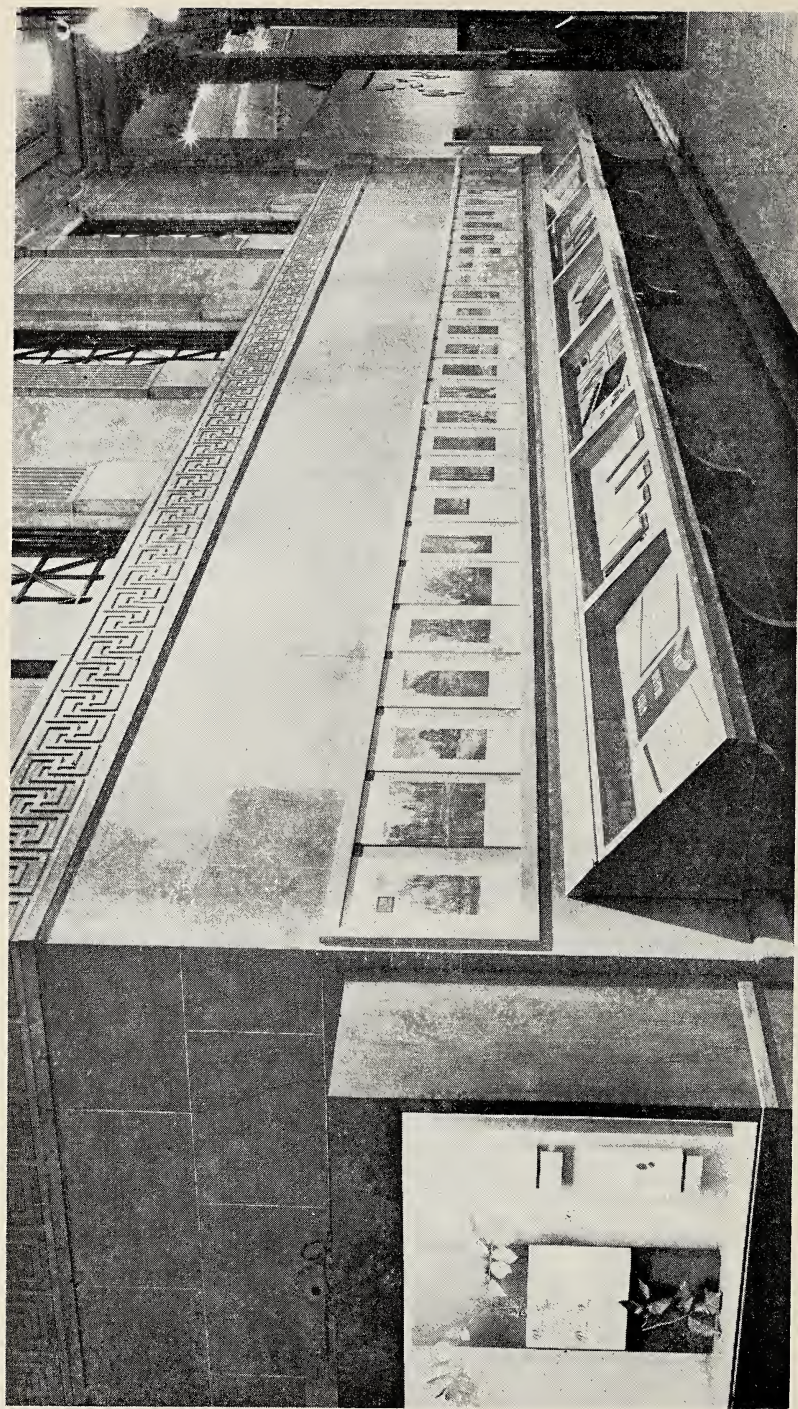
A new home for the State Museum has been the objective of planners at intervals over the past four decades or longer. On each occasion, hopes were dashed and the plans were returned to the files. At the present point in Museum history, therefore, it may be too early to state that the revival of planning for a modern building was potentially the most far-ranging activity of the staff during 1962-63. However, progress on the new State administrative center in downtown Albany and the inclusion of a museum building in its blueprints indicates that this time the project will become a reality. Accordingly, sometime was spent, primarily by the Assistant Director and the Museum Education staff, in reviewing existing plans and drawing up new preliminary information for the architects.

Meanwhile, the present Museum continued the established program to promote better understanding of the natural sciences, to increase and care for the State's scientific collections, and to make the Museum facility more comfortable and attractive to the public.

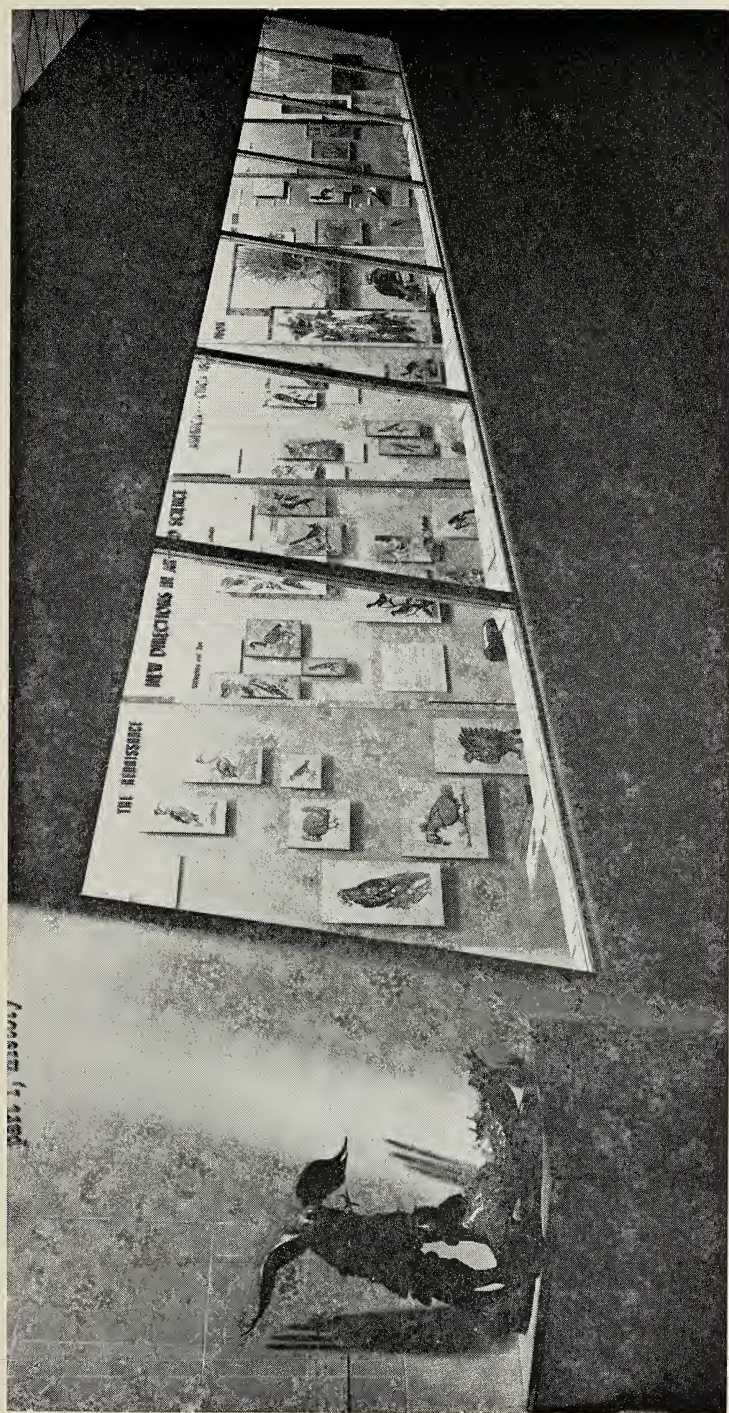
Improvement of portions of the building now occupied by the Museum continued. Skylights over the western half of the Washington Avenue section were sprayed with material which formed a waterproof coating, excluding light as well as rain from Geology Hall, the mineral room, and the foyer. While the artificial illumination in the first two areas is now constant, it is grossly inadequate at the exhibits level. Visitors in the mineral room have been seen using flashlights which they had forehandedly brought to the Museum in order to study the specimens and read the labels.

The "quiet" room which was built in the Herbarium during the year has been satisfactory in all respects. It provides a spacious, well-lighted area for research on the collection without the distracting noise which at times pervades the Herbarium proper from the public space in Biology Hall. Scheduled air conditioning had not been installed at the end of the year.

Among the notable foreign visitors who had professional or technical interest in the Museum program were the Director of Basic Education and Culture for East Java, Republic of Indonesia, and the Assistant Director of the Cape Town Museum, Cape Town, S.A. A group of trainees for the U.S. Peace Corps who were being prepared for assignment to countries in western Africa were given a lecture



One of the corridors to Biology Hall before modernization. See following page.



The history of ornithological art is explained in one of two exhibits in the corridors to Biology Hall. Attractiveness of the display is enhanced by the modern setting which was created in an old-fashioned hall. See preceding page.

and an interpretation of exhibits as part of their study of the State Education Department.

At their request, a number of institutions in the State, as well as several elsewhere, were advised on problems concerning management, collections, and exhibits. Among them were the Elwood Museum at Amsterdam, the Nassau County Department of Public Works, and a newly organized museum at Santa Rosa, Calif. The Assistant Director participated in a ceremony at which a Regents charter was given to the Valley Stream Museum.

He made studies of building layout, traffic flow, and exhibit design and techniques at institutions in New York City, Washington, D.C., and Seattle. Ideas obtained at the U.S. Science Exhibit at the Seattle World's Fair, which was visited in connection with participation in the First World Congress on National Parks, were especially valuable. Information accumulated in these and many other studies during previous years was put to use in preliminary recommendations requested by the architects of the proposed State government center, which will include the new State Museum.

Thanks to the efforts of the staff and the generosity of numerous friends, the collections were increased in several fields of science. A considerable number of mineral specimens, including some unusual and spectacular pieces, were donated by Elmer B. Rowley, Glens Falls. The Museum gained in one instance through misfortune; two Przhevalski horses and a European Bison that died in accidents at the Catskill Game Farm were turned over to us by that institution for preservation. Complete skeletons as well as the skins were saved by the Museum exhibits preparators. The considerable number of Old World mammals which was donated in recent years by Dr. and Mrs. W. Brandon Macomber, Albany, was increased in 1962-63 by the gift of 32 specimens, mostly from East Africa. This generous offering will be doubly appreciated in years to come when space will be available for their display in a larger building. Many of the species represented in the donation are becoming progressively more scarce and difficult to obtain. Twenty-one individuals and institutions donated items for display in the exhibit on "Bird Art in Science." Among these objects were an engraving and the original copper plate showing waterfowl in action, sent by the maker, Richard E. Bishop, Philadelphia. Original paintings of birds were contributed by the artists, Don Eckelberry, Babylon, N.Y., Francis Lee Jaques, St. Paul, Minn., and Roger Tory Peterson, Old Lyme, Conn. A plate from the first (folio) edition of Audubon's *Birds of America* was purchased especially for the exhibit and presented by Dr. and Mrs. W. Brandon Macomber.

More publicity of direct assistance in public use of the exhibit halls was obtained from the news media than in previous years. The Radio-TV Bureau of the New York State Department of Commerce performed a real service by furnishing "shorts" concerning the Museum and its schedule to approximately 200 radio and 30 television stations in New York State. The use of these brief statements in breaks between programs called attention to the Museum and special exhibits and were particularly important in informing the public of the radical changes in Sunday openings (from summer to spring and fall). We also supplied this information to radio-TV stations in southwestern Vermont and western Massachusetts.

Newspapers in Albany, Troy, Altamont, and other communities were also furnished with information and carried stories accordingly. Several subjects, such as exhibits modernization, were printed with illustrations in the Albany papers.

In a further effort to publicize the Museum, especially among educators and others concerned with the schools, information folders were distributed at more than a dozen statewide meetings and conventions of teachers, school administrators, parent-teacher groups, etc.

A 30-minute television show describing the program of the State Museum was taped in the offices, laboratories, and exhibit halls under the direction of Mrs. James O. Moon and Mrs. Henry Hund, of the Mohawk Hudson Council on Educational Television. It was run four times by Station WHMT during the calendar year 1963 after its production in January. The show was a simplified account of curatorial work, exhibits preparation, education, and administration. Despite great condensation and quick production, it was an accurate and comprehensive story which aroused considerable interest whenever it was shown.

As stated in several previous annual reports, visitor use of the exhibit halls on Sundays in summer had declined to the point that the use of funds for guards and elevator operators was hardly justifiable. Attendance on Saturdays in spring and fall, however, was large and increasing. Accordingly, after ample publicity, the traditional Sunday openings were shifted from the summer months of 1963 to spring and (in the next annual reporting period) fall. The results confirmed the belief that more persons would benefit by the change. Total attendance on the 13 Sundays, March 3 through May 26, was 7,421 persons. On one Sunday, March 24, 966 visitors were counted. On only one day, April 14 (Easter), did the tally drop below 400 to 366. Average attendance for the 13 Sundays was 571, approximately double that for Sundays in summers of the several previous years.

Partly as a result, visitor attendance for the year totaled 213,000,

an increase of more than 4 percent over that for 1961-62. The largest single day was March 16 (St. Patrick's Day parade) when 2,117 persons came to the Museum. The highest count on a nonholiday, 1,616, was made on May 9 (a Thursday) and the lowest, 294, was recorded January 16 (a Wednesday).

The exhibits program became more diversified in 1962-63. Paleontology continued to receive considerable attention; fossil-bearing slabs and modelled restorations of animals were installed on the pillars in the mollusk alcove and the arthropod alcove, and dioramas showing life in the Ordovician black shale and the Devonian normal marine environments were initiated. Plans were drawn and a scale model was constructed for the case, to occupy the northeast quarter of the Hall of Ancient Life, in which a panoramic display of the vertebrates will be housed. However, work on this final unit in the hall was not started because of the need to carry out major exhibits in two other fields.

Plans for a rather extensive exhibit-story of the role that art and artists can play in the science of ornithology were drafted early last year. In October 1962, the services of Richard L. Scheffel were secured to improve the plan where possible, to procure the numerous items required for display, to write the many labels, and to give technical guidance to the Design Office in assembling the exhibit. With the assistance of generous donors (see p. 30) and of Mr. Koster and his staff, Exhibits Designer Theodore Weyhe and his assistant Miss Rothman produced a striking show consisting of 14 panels. All except two of these sections had been installed at the end of the year in the corridors between the rotunda and Biology Hall. By this time, Mr. Scheffel had nearly completed a manuscript for an educational leaflet which will enable teachers to interpret the exhibit to their classes without the direct assistance of our instructors. The publication will also be interesting and useful to that large segment of the public known as bird watchers.

Work on another exhibit of a biological nature, "The Reptiles of New York," was commenced. Using principally casts and models on hand, but with new items added as necessary, the display will consist of four units devoted to snakes, lizards and salamanders, turtles, and frogs and toads, respectively. A special temporary show was also created in Biology Hall to utilize some of the many original paintings by Louis Agassiz Fuertes which could not be used in the "Bird Art in Science" exhibit.

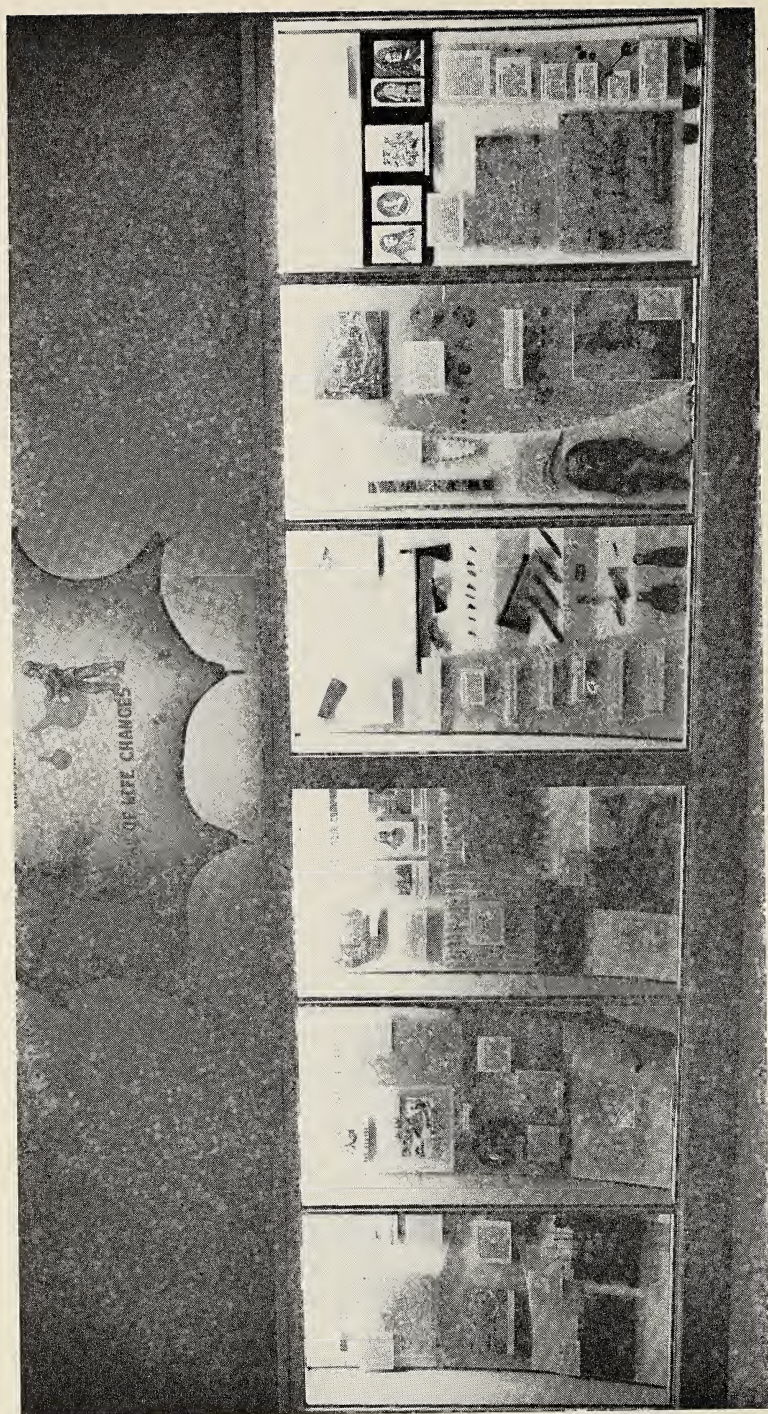
A three-section exhibit consisting of 27 panels was assembled to describe (1) the Iroquois fur trade with the Dutch, (2) pre-Columbian Indian life as interpreted from the excavations at the Garoga site, and

(3) post fur trade life of the Iroquois, as demonstrated by material from the Morgan Collection which had been presumed lost in the Capitol fire of 1911 but which has since been reidentified by the Curator of Archeology. The plans for parts 1 and 3 were worked out by Messrs. Funk and Gillette, respectively, while the main exhibit on the fur trade itself was planned by Dr. C. P. Russell, Orinda, Calif., formerly in charge of the museum and natural history programs of the National Park Service. Most of the objects in the exhibit were taken from the Museum's collections, but several items vital to the story were obtained on loan through the generous cooperation of the Albany Institute of History and Art, the Fort Orange Club, Albany, and Fort Ticonderoga. A temporary display of original documents, prints, and early books on the Iroquois-Dutch fur trade was created by the staff of the State Library. The exhibits were completed for the annual meeting of the American Indian Ethnohistoric Conference, but all except the State Library's material will remain on view indefinitely. (At the close of the Conference, the Museum's collection of Iroquois masks was the subject of a special ceremony performed by Corbett Sundown, a Seneca from the Tonawanda Reservation. This traditional rite, in the nature of an apology or condolence, is performed whenever the masks change hands or, as in this instance, they have not been the subject of proper ritual care by the Seneca for a period of time. Although whites are normally excluded, Chief Sundown permitted those attending the Conference to observe the ceremony and hear the ancient chants.)

Other noteworthy occurrences in the exhibits field were the display of seven demonstrations by the winners of Regional Science Congresses, and the installation of a protective alarm system for the Iroquois wampum belts. The latter display was also repainted and made more attractive.

The demand for educational services has continued to grow. Thanks to Federal assistance through the NDEA (Title III) program, this increased need has been met fairly satisfactorily. However, a considerable number of requests from schools was necessarily refused during the busiest month (May), when more than 8,000 children received instruction. With the present staff of four persons available for teaching, no more classes could be handled without lowering the quality of instruction and placing an unreasonable overload of work on the personnel.

Total group attendance was nearly 33,000 children. This relatively small decrease of 3 percent from the figure in 1961-62 was due almost entirely to a decline in the school groups which came to the Museum without requesting appointments for instruction by the Museum staff.



Central section of a 27-panel exhibit on the Iroquois — Dutch fur trade, which was completed for the American Indian Ethnohistoric Conference and will remain on view indefinitely.

However, the number of school children who came in classes for such instruction rose from 21,369 in 1961-62 to 22,284 — an increase of more than 4 percent. The percentage of children in school groups who attended Museum classes during their visits also rose from 73 percent in 1961-62 to slightly over 80 percent in 1962-63.

Another increase in the work load on the Museum education staff resulted from doubling the workshop program for teachers in public and other schools. Assistance was contributed by the Curators of Entomology and Zoology, who conducted 2 of the 23 sessions for a total of 585 teacher-lessons. In this and other extensions of their routine assignments, such as handling loan exhibits and the Science Congress programs, giving special instruction to Girl Scouts and other young people, and running a series of natural science films that attracted 400 summertime visitors, the staff has shown alertness and industry.

Last year the Legislature enacted Chapter 177, Laws of 1962, permitting the State Museum to accept the services of volunteers who would be entitled to workmen's compensation if injured on the job. A conference was held with the placement officer for the Albany Junior League, but no member expressed an interest in manning the information-sales desk. However, later in the year a group of local Girl Scout officials proposed that interested Scouts be allowed, after adequate instruction, to work as museum volunteers. As a result, some help was provided to several Curators in after-school hours, and to the Museum guards on Saturdays when the girls took care of the sales desk. In turn, the Scouts earned merit badges. One adult contributed services (receiving our thanks in lieu of a badge!): Dr. Orra A. Phelps, Wilton, spent many hours mounting plant specimens in the Herbarium.

The sales desk, with Museum Custodian William Zimmer in charge, is conducted solely as an educational service to the visiting public in order to make available inexpensive books and pamphlets of proven value and objects which are likely to stimulate interest in the natural sciences. An increase of more than 30 percent in the volume of sales over that in the previous year is noteworthy, therefore, as an educational achievement rather than as a financial success. It has, however, made it possible to hire a part-time receptionist during the busiest months, augmented by the occasional services of Girl Scouts (see p. 41). Guards have thus been afforded more time to patrol the exhibit halls and to give greater assistance to the education staff in handling large groups of schoolchildren and others. Mrs. Paula Hysler, the new receptionist, has been an excellent choice to make better service available to visitors at the information-sales desk.

Curatorial Activities

ARCHEOLOGY

The Curator continued to move items from old exhibits, which were being dismantled, into the research collection. New materials collected by the State Archeologist and assistants at the Garoga, Lamoka Lake, and O'Neil sites were processed. Additions were made to the site records, accessions records, and the Museum's central photographic negative file. Requests for information by more than 200 visitors to the office, and many additional inquiries by telephone and mail, were answered.

In addition to routine care of the collections, the Curator participated in planning and installing a special exhibit: "The Iroquois Indian and the Fur Trade."

During the school year 1962-63, the Curator had the assistance of three Senior Girl Scouts as "Museum Assistants" over a period of 5 months. Although rather close supervision was required at times, they gave nearly 70 hours of faithful and conscientious service. As an index of interest, two of the girls volunteered to work beyond the time required to obtain their badges.

BOTANY

All unmounted collections of bryophytes and fungi to date were processed, except for the accessions of the current spring. Sight-records of vascular plants were recorded on the map-files of the Herbarium. Dr. Orra A. Phelps, Wilton, N.Y., was employed for 2 weeks in March, transferring data of the moss collections to map-cards for the purposes of mapping distributions. Dr. Phelps generously contributed many additional hours in April and May in order to complete the mounting of specimens. All vascular plants have been sorted by orders and placed on recently constructed storage shelves in the Herbarium. All specimens of cryptogamic vasculars, conifers, and grasses have been verified and recorded on our maps and a start has been made on the remainder of the monocots. During the fiscal year, the Curator's assistant found a fungus which Dr. Clark T. Rogerson, of the New York Botanical Garden, claims is apparently new to North America.

The following additions were made to the data of the State checklist of mosses, some identifications being made by Dr. Howard E. Crum, National Museum of Canada: District 3 (vicinity of Saranac Lake), 1; District 4 (vicinity of Plattsburgh), 4; District 17 (vicinity of Middleburg), 2, and District 21 (vicinity of Poughkeepsie), 5. One species was added to the known moss flora of the State. Most of the recent moss collections are still to be identified.

The Curator has continued recording specimens on distribution maps. This project, coupled with the sight-records, has added the following numbers of species and subspecies of vascular plants to our county lists:

Albany	7	Greene	13	Richmond	1
Alleghany	3	Hamilton	17	Rockland	7
Bronx	2	Herkimer	2	St. Lawrence	15
Cattaraugus	18	Lewis	3	Saratoga	20
Cayuga	7	Livingston	12	Schenectady	24
Chautauqua	35	Monroe	1	Schoharie	6
Chemung	2	Montgomery	2	Seneca	4
Clinton	13	Nassau	7	Steuben	3
Columbia	4	Oneida	1	Suffolk	31
Cortland	1	Ontario	6	Sullivan	1
Delaware	20	Orange	3	Tioga	2
Dutchess	19	Orleans	1	Tompkins	5
Erie	6	Oswego	2	Ulster	4
Essex	25	Otsego	5	Warren	11
Franklin	11	Putnam	1	Washington	1
Fulton	12	Queens	39	Wayne	73
Genesee	1	Rensselaer	7	Westchester	7

Included in these records, in addition to the grasses mentioned above, were 12 new species and one new subspecies for the State.

Four institutions and 17 individuals presented materials in exchange or as gifts (see page 33). These accessions are classified as follows:

	FUNGI	ALGAE	BRYOPHYTES	VASCULAR PLANTS	TOTAL
New York State	68	0	107	118	293
Out-of-State	13	1	1	244	259
Total	81	1	108	362	552

Collections by the Curator and his assistant were as follows:

New York State	805	8	2,943	436	4,192
Out-of-State	132	0	211	8	351
Total	937	8	3,154	444	4,543

In addition, the holder of a Student Honorarium collected 238 fungi.

The most notable accessions were 1,024 collections of bryophytes from New York State which were collected by the Curator's assistant, Norton G. Miller, and 238 specimens of lichens from Long Island, collected by Dr. Irwin H. Brodo, Michigan State University, recipient of a Student Honorarium.

ENTOMOLOGY

The Curator answered about 250 queries concerning insect identification and control, maintained and augmented the insect collection, continued his research on taxonomy of the leaf beetles, prepared small exhibit cases, and instructed several groups of schoolchildren.

Cooperative work with the Forest Pest Bureau, New York State Department of Conservation, required identification of forest pests, while assistance to the New York State Department of Health called for identification of mites, ticks and fleas, and small animal parasites. Insect exhibit material was loaned to: Seventh Day Adventist Junior Camp at Auburn, Bethlehem Central High School at Delmar, and the New York State Department of Agriculture and Markets at Albany.

GEOLOGY

The Curator of Geology continued his study of the clay minerals present in the Lower Devonian rocks of the central Hudson Valley. A rare chlorite mineral was discovered and is being subjected to intensive investigation.

Approximately 1,000 sets of New York State rocks and minerals were assembled by students under the Curator's supervision for sale at the Museum Information Desk.

Approximately 210 rock, mineral, and ore samples were identified for the public and/or colleagues; 80 of these identifications were made using X-ray techniques. Of 215 inquiries answered during the year, 75 concerned geology and 55 were on mineralogy of the State, while 85 could be classified only as miscellaneous.

Members of the Capital District Mineral Club donated new specimens for the temporary exhibit in Orientation Hall illustrating minerals which can be collected in New York State. The Curator assisted in the revision of this exhibit.

PALEONTOLOGY

One hundred and eighteen specimens were added to the type collections; 49 type specimens were treated to stop or prevent disintegration. Collections containing approximately 214 specimens were shipped to institutions and colleagues for study. One hundred and fifty-six entries were made in the locality-accession records, and 318 specimens were ticketed with locality numbers. As usual, a considerable amount of time was spent in keeping the type catalog up to date. The State Paleontologist and the Senior Scientist (Paleontology) turned over for accessioning in the collection a total of 207 specimens from 10 localities in Illinois, Indiana, and New York.

Assistance was given to the following visiting scientists who desired to study portions of the collections: Roger Batten, American Museum of Natural History (fossil gastropods); James D. Grierson, Cornell University (fossil plants); Ronald E. Janowsky, State University of New York at Buffalo (fossil brachiopods); William A. Oliver, Jr., United States Geological Survey, Washington, D.C. (fossil corals); Frederick C. Shaw, Museum of Comparative Zoology, Cambridge, Mass. (trilobites); J. Keith Rigby, Brigham Young University, Provo, Utah (fossil sponges); G. Westermann, McMaster University, Hamilton, Ontario, Can. (graptolites and fossil brachiopods).

Winifred Haas, Geologische Institut der Universität, Bonn, Germany, was furnished two rubber casts of a trilobite type specimen. Approximately 100 fossil specimens were identified for some 45 visitors, and information on fossils and fossil localities was transmitted to a number of correspondents.

ZOOLOGY

Distribution files were maintained on animals of the State and maps for the bird handbook project were continued. A museum guidebook to the mammals of the State is nearly completed. Many letters to the editor of the *Conservationist* magazine were answered by the Curator. Work with Boy and Girl Scouts, 4-H clubs, and school groups was continued. Routine care of the collections was continued and a part of the fish collection was rearranged. Susan Staffa worked on the skeleton and shell collections during the month of June 1963, continuing work she had started the previous summer. Items totaling 666 were cataloged.

Accessions

The State Museum was the recipient of the following donations by generous friends:

ANTHROPOLOGY

Gros Ventres arrows (3)	CLAY O'DELL, Canada Lake, N.Y.
Peruvian pot	CHARLES K. WINNE, M.D. Albany, N.Y.
Flint samples	R. ARTHUR JOHNSON, Latham, N.Y.
Oseous material from Indian sites on Hudson River	CARL S. SUNDLER, Albany, N.Y.
Ohio pipestone samples	RAYMOND BABY, Columbus, Ohio
East African Chief's staff and small bust from Tanganyika	GOVERNOR NELSON A. ROCKEFELLER, Albany, N.Y.
Indian artifacts from Rondout Creek	HERBERT SMALL, Kerhonkson, N.Y.
Indian flint knife	HERMAN MEIER, Coxsackie, N.Y.
Volumes of photos of paintings of Indians by W. Langdon Kihn	EMIL F. TEICHERT, Lake Hill, N.Y.
Spears (4)	CHARLES W. BLACKLOCK, Albany N.Y.

BOTANY

Plants from northeastern North America (54)	THEODORE C. BAIM, Schenectady, N.Y.
Lichens from Long Island (238)	DR. IRWIN H. BRODO, State University, Michigan, East Lansing, Mich.
Vascular plants from northeastern United States (180)	DR. GEORGE R. COOLEY, Rensselaerville, N.Y.
<i>Monarda punctata</i> , ssp. <i>villiscaulis</i> from Rensselaer County	MRS. GEORGE R. COOLEY, Rensselaerville, N.Y.

<i>Riccia fluitans</i> from Ulster County	HENRY F. DUNBAR, Kingston, N.Y.
<i>Monocotyledoneae</i> from New York State (2)	NEIL HOTCHKISS, U.S. Dept. of Interior, Beltsville, Md.
Bryophytes from Delaware County (4)	DR. ANNA E. JENKINS, U.S. Dept. of Agriculture, Washington, D.C.
<i>Frommea obtusa</i> from Albany County	CLIFFORD A. LAMERE, Albany, N.Y.
<i>Chlorophyta</i> from northeastern United States (34)	NORTON G. MILLER, South Wales, N.Y.
<i>Polyporaceae</i> from New York State (7)	NEW YORK STATE COLLEGE OF FORESTRY, Syracuse, N.Y.
Plants from New York State (99)	DR. ORA A. PHELPS, Wilton, N.Y.
<i>Exobasidium vaccinii</i> from Columbia County	DR. EDGAR M. REILLY, JR., N.Y. State Museum, Albany, N.Y.
<i>Mycota</i> from eastern North America (16)	DR. CLARK T. ROGERSON, N.Y. Botanical Garden, New York, N.Y.
Plants from northeastern U.S. (23)	MRS. CLARA SCHULTZ, Stillwater, N.Y.
Plants from Ulster County (7)	DANIEL SMILEY, Mohonk Lake, N.Y.
<i>Anthopsida</i> from Allegany County (48)	RALPH H. SMITH, N.Y. State Conservation Dept., Albany, N.Y.
<i>Physalis heterophylla</i> from Seneca County	R. ELIOT STAUFFER, Rochester, N.Y.
<i>Corticium</i> from Albany County	JOHN A. WILCOX, N.Y. State Museum, N.Y.
<i>Erysiphe</i> from Albany County	MRS. CHARLES WINSLOW, Albany, N.Y.

ENTOMOLOGY

Fleas (475)	A. H. BENTON, Albany, N.Y.
Forest pest specimens (100)	D. P. CONNOLA & W. E. SMITH, Albany, N.Y.
Biting flies	HUGO JAMNBACK, Albany, N.Y.

EXHIBITS

Reproductions of color photos	ARTHUR A. ALLEN, Ithaca, N.Y.
Book; color plates from <i>Hummingbirds</i>	AMERICAN MUSEUM OF NATURAL HISTORY, New York, N.Y.
Copy of <i>The Auk</i>	AMERICAN ORNITHOLOGISTS' UNION, Chicago, Ill.
Engraving and copper plate	RICHARD E. BISHOP, Philadelphia, Pa.
Reproductions of color photos	CHANTICLEER PRESS, INC., New York, N.Y.
Book	CHICAGO NATURAL HISTORY MU- SEUM, Chicago, Ill.
Reproduction of painting	WILLIAM DILGER, Ithaca, N.Y.
Photographic prints	NICK DRAHOS, Albany, N.Y.
Original tempera painting	DON ECKELBERRY, Babylon, N.Y.
Original oil painting	FRANCIS LEE JAQUES, St. Paul, Minn.
Reproductions of engravings by A. Wilson	J. B. LIPPINCOTT CO., Philadelphia, Pa.
Plate from first edition of <i>Audubon's Birds of America</i>	DR. & MRS. W. BRANDON MACOMBER, Albany, N.Y.
Pamphlets and educational materials	NATIONAL WILDLIFE FEDERATION, Washington, D.C.
Pamphlets and reprints; color plates from Bump et al., <i>The Ruffed Grouse</i>	NEW YORK STATE CONSERVATION DEPT., Albany, N.Y.
Copy of <i>Bird-Banding</i>	NORTHEASTERN BIRD-BANDING ASSN., West Hartford, Conn.
Original crayon drawing	RONALD NORTHROP, Latham, N.Y.
Reproduction of painting by Roger T. Peterson	DR. RALPH PALMER, Feura Bush, N.Y.
Original paintings (2)	ROGER T. PETERSON, Old Lyme, Conn.
Book	DR. E. M. REILLY, JR., N.Y. State Museum, Albany, N.Y.
Book	STACKPOLE CO., Harrisburg, Pa.
Reproductions of paintings by Arthur Singer	WESTERN PRINTING & LITHO- GRAPHING CO., New York, N.Y.

GEOLOGY

Allanite crystal from Comstock

ELMER B. ROWLEY, Glens Falls, N.Y.

Apatite crystals in augite — sphene in scapolite — vesuvianite and pyroxene crystals — scapolite and graphite crystals — microcline with albite (moonstone) gem quality scapolite from Olmstedville

Beryl in quartz — dolomite crystals in beryl in quartz — muscovite with reticulated magnetite — hematite inclusions from Batchellerville

Biotite crystals from Queensbury

Crytolite crystals — polycrase — graphic granite from Day

Epidote crystals in quartz crystals from Warrensburg

Fluorite from Elizabethtown, Ky.

Garnet — serpentine from Willsboro

Gutermanite from St. Joseph Lead Mine, Balmat

Hornblende, albite, quartz, and epidote crystals — serpentine with epidote crystals — allanite crystals — epidote veins in diorite from Eagle Point, Schroon Lake

Magnesite on serpentine — green and amber serpentine — from Athol

Microcline crystal from Saratoga County

Muscovite pseudomorphous after diopside crystal, with tourmaline crystal — brown tourmaline crystals from Brant Lake

An extensive suite of rare earth *pegmatite* minerals including:

Uraninite — allanite with uranophane — portion of large single allanite crystals on pyrite — chalcopyrite and pyrite in pyrrhotite — gypsum crystals on pyrite — pyrite cap on pyrrhotite dike — uraninite, uranophane in feldspar — pickeringite on pyrrhotite — black tourmaline crystal — hyalite opal (fluorescent) — granular pyrite in feldspar — biotite from Essex County

Phlogopite crystals from Talcville

Pyrite crystals in talc and prochlorite from Chester, Vt.

Quartz crystals from Lyndhurst, Ontario, Can.

Quartz crystal (rounded faces) from Chilson Hill, Ticonderoga

Quartz — epidote gneiss from South Bay Rock Quarry, Whitehall

Quartz crystals — hydrocarbon in calcite — calcite, dolomite, and quartz crystals on limestone — cerussite coating dolomite crystal with quartz crystals from Gailor quarry, Saratoga

Selenite crystal group from Penfield

Serendibite (2d known world occurrence), sinhalite, phlogopite in diopside — serpentine with magnesite rim — diopside crystals from Johnsburgh

Black tourmaline crystal in quartz from South Bay Bridge, Whitehall

PALEONTOLOGY

Pelvic area of giant sloth skeleton, Pleistocene from Newburgh

GERALD ILLENBERG, Middletown,
N.Y.

Ordovician graptolites (15)
Slab containing brachiopod
specimens, Triassic, North
Bergen, N.J.

WILLIAM KLOSE, Troy, N.Y.

ROBERT SALKIN, Newark, N.J.

ZOOLOGY

Bird specimen

ALTAMONT ELEMENTARY SCHOOL,
Altamont, N.Y.

Przhevalski horses (2)
European Bison Wisent

CATSKILL GAME FARM, Catskill,
N.Y.

Field collection of mammal
specimens (54)

PAUL F. CONNOR, N.Y. State Mu-
seum, Albany, N.Y.

North American mammals
(5) ; African mammals (26)
and Asian mammal

DR. & MRS. W. BRANDON MACOM-
BER, Albany, N.Y.

Snow geese specimens (2) ;
mammal skulls (63)

N. Y. STATE CONSERVATION DEPT.,
Albany, N.Y.

Bird specimens (5)

MRS. DONALD RADKE, East Chat-
ham, N.Y.

Ruby-throated hummingbird

MRS. SHAW, Albany, N.Y.

Copperhead ; red-tailed hawk ;
brown creeper and white-
footed deer mice (3)

HENRY THURSTON, Claverack,
N.Y.

Mammal specimens (44)

J. WHITAKER, JR., Cornell Univer-
sity, Ithaca, N.Y.

Donations

Duplicate and other materials which were excess to needs were donated to individuals, schools, and cooperating institutions which expressed need for them:

GEOLOGY

Mica crystals

GENERAL ELECTRIC RESEARCH LAB-
ORATORY, Schenectady, N.Y.

Graphite crystals

U. S. ARMY SIGNAL RESEARCH &
DEVELOPMENT LABORATORY, Fort
Monmouth, N.J.

PALEONTOLOGY

Fossil specimen
Fossil specimen
Fossil tree stump

ANNE GUELKER, St. Louis, Mo.
PHILIP RAMSEY, Benwick, Me.
UNIVERSITY OF OKLAHOMA, Norman, Okla.

Exchanges

BOTANY

Plant specimens from 5 continents (69)

MISSOURI BOTANICAL GARDEN, St. Louis, Mo.

Chamberlainia acuminata from Illinois

NATIONAL MUSEUM OF CANADA, Ottawa, Can.

Chamberlainia cyrtophylla from Orange County

N. Y. BOTANICAL GARDEN, New York, N.Y.

PALEONTOLOGY

Graptolites from New York State for graptolites from Europe

HERMANN JAEGER, Institut und Museum für Paläontologie der Humboldt-Universität, Berlin, East Germany

Loans

The following loans were made on request of schools, other institutions, and of scientists:

ARCHEOLOGY

String of glass beads

SARATOGA NATIONAL BATTLEFIELD PARK, Saratoga Springs, N.Y.

Plastic casts of projectile
points
Western Indian ethnological
specimens (5)

STATION WMHT, Schenectady, N.Y.
BETHLEHEM PUBLIC SCHOOLS,
Delmar, N.Y.

BOTANY

Type specimen of *Hydnum*
marcescens

NEW YORK STATE COLLEGE OF
FORESTRY, Syracuse, N.Y.

Specimen of *Frullania ebora-*
censis

STATE UNIVERSITY OF NEW YORK
AT BUFFALO, Buffalo, N.Y.

Type specimens of *Russula*
(7)

UNIVERSITY OF MICHIGAN, Ann
Arbor, Mich.

Type specimens of *Crepidotus*
(15)

UNIVERSITY OF TENNESSEE, Nash-
ville, Tenn.

Isotype of *Gyroceras divergens*

COMMONWEALTH MYCOLOGICAL
INSTITUTE, Kew, Surrey, Eng-
land

PALEONTOLOGY

Type specimen of fossil brach-
iopod

DR. THOMAS W. AMSDEN, Oklahoma
Geological Survey, Norman,
Okla.

Type specimen of fossil plant

DR. HARLAN BANKS, Cornell Uni-
versity, Ithaca, N.Y.

Mammoth atlas

RICHARD S. CAREY, Nassau County
Museum, East Meadow, N.Y.

Fossil plant specimens (26)

JAMES D. GRIERSON, Cornell Uni-
versity, Ithaca, N.Y.

Fossil cephalopod specimens
(40)

DR. MICHAEL HOUSE, University of
Durham, Durham, England

Type specimens of fossil bra-
chiopods (8)

RONALD E. JANOWSKY, State Uni-
versity of New York at Buffalo,
Buffalo, N.Y.

Eurypterid specimen

ERIK N. KMELLESVIG-WAERING,
Port of Spain, Trinidad, W.I.

Type specimen of fossil crin-
oid

DR. JOHN W. KOENIG, Missouri
Geological Survey and Water
Resources, Rolla, Mo.

- Type specimens of fossil gastropods (9) DR. ROBERT M. LINSLEY, Colgate University, Hamilton, N.Y.
- Type specimens of fossil ostracodes (7) DR. D.M. LORANGER, Imperial Oil Enterprises, Ltd., Calgary, Alberta, Can.
- Fossil pelcypod specimens (7) DR. C.W. MERRIAM, U.S. Geological Survey, Menlo Park, Calif.
- Type specimens of fossil corals (5) DR. WILLIAM A. OLIVER, JR., U.S. Geological Survey, Washington, D.C.
- Type specimens of fossil corals (2) DR. A. E. H. PEDDER, University of New England, Armidale, N.S. W. Australia
- Type specimens of fossil pelcypods (49) JOHN POJETA, JR., University of Cincinnati, Cincinnati, Ohio
- Fossil sponge specimens (190) DR. J. KEITH RIGBY, Brigham Young University, Provo, Utah
- Type specimens of graptolites (69) DR. JOHN RIVA, McGill University, Montreal, Can.
- Type specimens of fossil brachiopods (2) DR. REUBEN J. ROSS, JR., U. S. Geological Survey, Denver, Col.
- Type and nontype specimens of trilobites (38) FREDERICK C. SHAW, Museum of Comparative Zoology, Cambridge, Mass.

ZOOLOGY

- Birds (24) ALTAMONT ELEMENTARY SCHOOL, Altamont, N.Y.
- Mammals (88) DUKE UNIVERSITY, Durham, N.C.
- Mounted bear ELSMERE GRADE SCHOOL, Elsmere, N.Y.
- Birds (10) GUILDERLAND ELEMENTARY SCHOOL, Guilderland, N.Y.
- Bird specimens (24) MRS. G. T. PARKER, East Greenbush, N.Y.
- Birds and mammals (14) SCHENECTADY PUBLIC SCHOOLS, Schenectady, N.Y.
- Snakes (3) ST. JOSEPH'S SCHOOL, Albany, N.Y.
- Fish specimens (503) VIRGINIA POLYTECHNIC INSTITUTE, Blacksburg, Va.

Museum Exhibits

PLANNING AND DESIGN

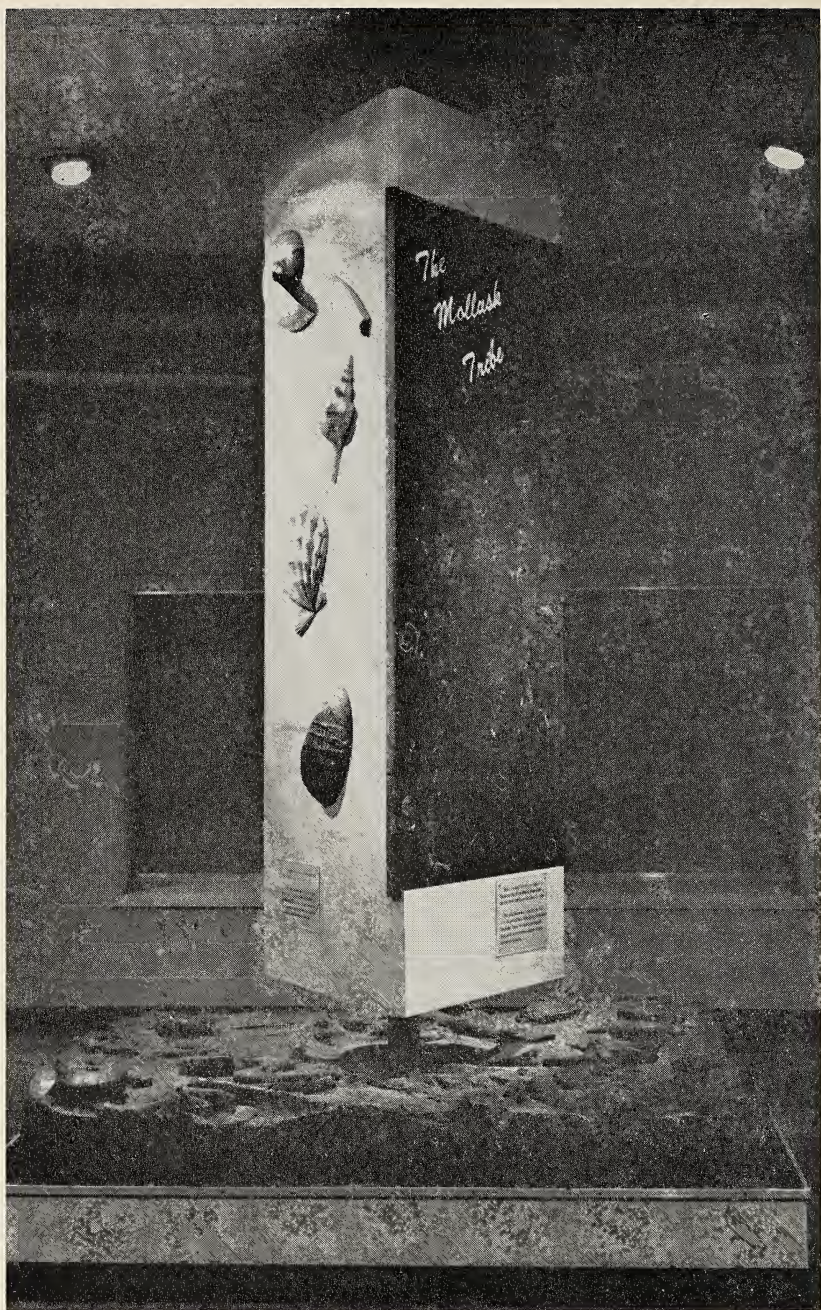
Detailed plans were drawn for the final major structure in the Hall of Ancient Life and a 5-foot model was constructed. In general form it is a companion piece to the paleoecology section which was built last year, but features an unbroken panoramic setting for the display of vertebrate evolution. Two dioramas, "Ordovician-black shale" and "Devonian-normal marine" were designed and executed in working scale models. Accessories and labeling were installed on both the cephalopod-mollusk pillar and the eurypterid-trilobite pillar, in the south wall of exhibits.

Based on plans by Dr. C. P. Russell, formerly chief of the museum and natural history programs in the National Park Service, a series of 27 permanent exhibits was prepared to tell the story of the Iroquois-Dutch fur trade. Three large master labels and illustrations were completed on simulated stretched hide. A scale model was made for a display unit to house a collection of skull casts to explain the history of man.

The exhibit titled "Bird Art in Science" was largely complete by the end of the year. A modern setting was designed to display some of the Museum's collection of Fuertes' original paintings of New York birds. Two clusters of spotlights were arranged to illuminate the casts of marine animals which have been suspended from the ceiling of Biology Hall.

Cases and labeling were prepared for the exhibits of seven Regional Science Congress winners. Two demonstration carts were designed for the Museum Education section. A copy of the new Geologic Map was mounted, cut out, and arranged against a setting of birch veneer in a basket-weave pattern for the office of the Geological Survey. A self-leveling projector stand was developed for the Seminar Room to compensate for the uneven floor and provide vibration-free viewing.

Cartoons and illustrations were drawn for several Museum publications, including *The Empire State Geogram*, *Mammals and Mastodons of New York State*, *The Oldest Forest*, a Graduate Student Honorarium flyer, and *Geology of the Adirondacks*.



Two fine slabs, containing numerous cephalopod fossils which had been in the Museum for many years, were mounted with new restorations for a striking identification of the mollusk alcove in Paleontology Hall.

PREPARATION

The major projects were two dioramas for Paleontology Hall. Specimens and accessory materials were assembled and installed in the Devonian-normal marine diorama and the painting for the background was begun; specimens were also assembled for the Ordovician-black shale diorama and installation commenced. The replica of an ocean surface for the latter exhibit was being installed at the end of the year, and the lower portion of the diorama was being developed to portray deep sea luminescence by means of black light and fluorescent paint. Captions were lettered on the mollusk pillar exhibit.

A number of bird specimens were prepared for the bird art exhibit and a small habitat group of eastern redwings was constructed. Replicas were made of several kinds of turtle and snake eggs for the exhibit on the reptiles and amphibians of New York. The replica of a snapping turtle nest was prepared, bases were made for newly acquired specimens, construction of exhibit case interiors was continued, case panels were painted, exhibit lighting was installed, and a considerable number of labels were made and installed.

A fiber glass replica of an Indian girl was made for installation in the barkhouse. A number of fossil bones were treated to prevent exfoliation; tree specimens were prepared for study. Several bird nests were prepared for shipping as loan material, and a mammoth tooth was restored.

THE PUBLIC

The annual attendance based on systematic samplings was 213,300 persons. Attendance was: weekdays 161,500, Saturdays 32,500, Sundays 12,100, and holidays 7,200. This year, Sunday openings were shifted from summer to the period of March 3d through the end of May. During March, as many as 966 people visited the Museum on a single Sunday.

The Department Nurse was called to attend two visitors who were ill. Three others, less seriously affected, did not require aid.

In addition to protecting the exhibits and visitors, answering inquiries, and selling educational publications, the guard staff performed a great variety of other tasks.

A part-time attendant was hired with proceeds from the Sales Fund for the Information Desk. This released the Guards to patrol the halls during the busy season with the school classes. Girl Scouts also aided at the desk on certain afternoons; after training, they conducted simple tours of exhibit halls to groups of youngsters and others on Saturdays.

Special Services

MUSEUM INTERPRETATION — EDUCATION PROGRAM

The expanded program of the Museum Education Office continued and, in addition to its regular schedule, that office performed numerous and varied services, from assistance in planning and carrying out the program of the joint American Indian Ethnohistoric-Iroquois Conference, held in Albany this year, to entertaining professional colleagues from as far away as Pakistan and Sumatra, and judging local Science Congress Fairs.

In the meantime, with an eye to the future, considerable time and thought were given to the probable space requirements of Museum Education services in the projected new museum building, and early in June a 16-page report was submitted.

In collaboration with the Bureau of Statistical Services, a new method of recording and processing group attendance data was tested. After certain modifications, the new system seems to be working fairly well.

COLLECTIONS AND EQUIPMENT

The Education Office's collections of material for loan (outside Museum) and instruction (inside Museum) were reorganized, tabulated, and provided with protective housing. A number of bird study skins and marine and herpetological specimens were acquired through purchase and collection by Departmental personnel.

Aquaria and terraria were maintained as live teaching displays. A young racoon, kept for several months, provoked tremendous interest among visiting school groups.

One of the classrooms was refurbished with a wall display of duplicates of handling materials for easy reference during class sessions. Two teaching carts, designed by the Education Supervisor and built by the Museum carpenters, now facilitate the use of either of the two classrooms for any subject matter, serving both as storage bins and lecture stands.

The original mechanism of the Little Theater (slide shows), which had become defective through long and continuous use, was replaced by making a simple modification on a Kodak Carousel projector. Two new shows were assembled.

INSTRUCTION FOR VISITING GROUPS

The total number of children visiting the Museum in groups was 32,945. Schoolchildren in groups numbered 29,071. Of this attendance, 23,385 were given instruction. The total number of teachers involved in these classes was 1,806 and other adults numbered 2,137. In terms of Museum Instructor work load, the heaviest month was May, when some 8,000 schoolchildren attended classes. Still topping the list of subjects requested is the lesson on the Iroquois Indians, with heavy demands (25 percent of the total) from fourth and seventh grades.

TEACHER WORKSHOPS

The Teacher Workshop program, aimed at strengthening and enriching the content of subject matter for teachers, was approximately doubled this past year. Five hundred and eighty-five teachers attended 23 sessions covering 12 different subjects. Two of the workshops were conducted by the Curators of Entomology and Zoology.

SCIENCE CONGRESS PROGRAM

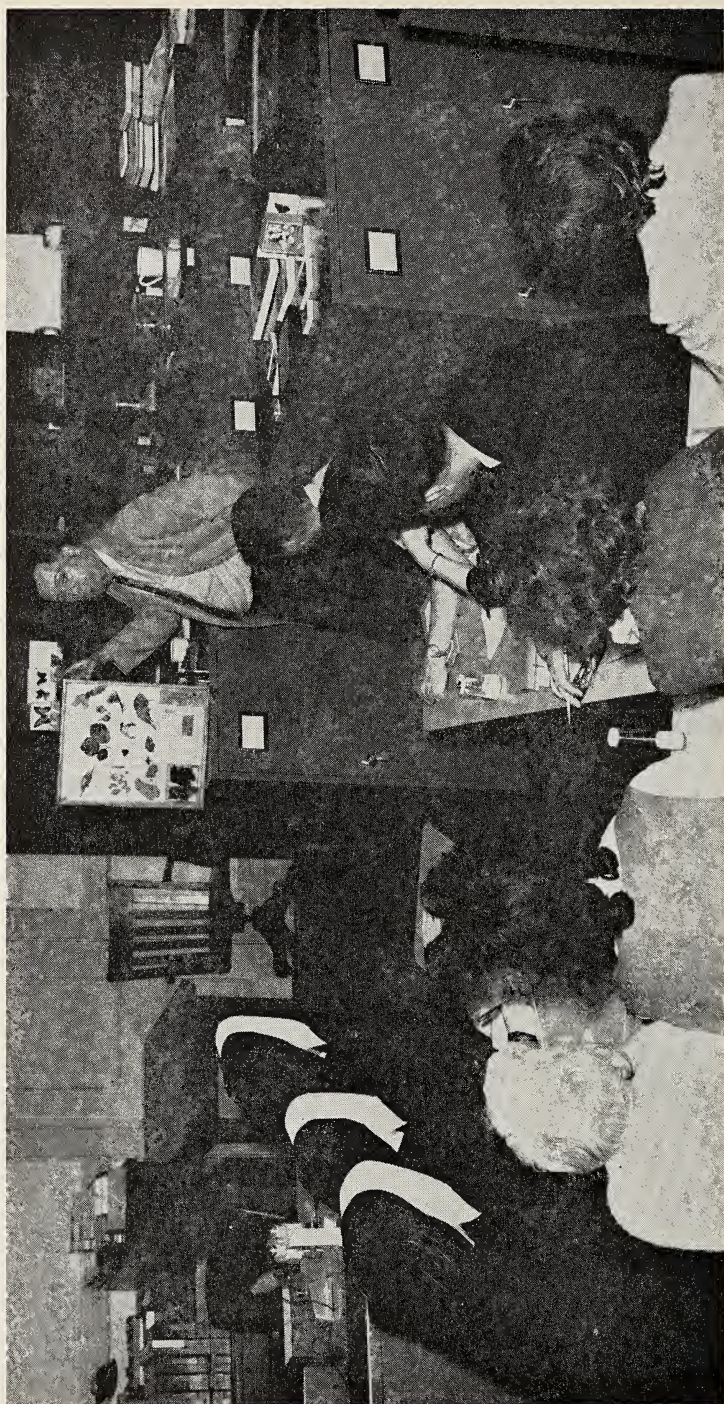
The Education Office staff arranged for four Regional Science Congress winners to visit a number of institutions in the area, including Bender Health Laboratories, General Electric Research Laboratories, the Delmar Game Farm (the N.Y.S. Department of Conservation), and individual offices in the Education Department. Each of the winning projects was exhibited for approximately two months in the Museum.

HIGH SCHOOL STUDENT PROJECTS

Nine high school students worked on their own projects under a program in zoology for teen-agers. On several occasions, the Curators of Botany, Entomology, and Zoology instructed groups both in the Museum and in the field.

GIRL SCOUT MUSEUM AIDE PROGRAM

A program for Girl Scout Museum Aides was begun. In eight two-hour sessions, 13 girls earned their Girl Scout Museum Bar. Seven girls stayed on to put in approximately 300 hours of their own time assisting at the Sales Desk and in the section of entomology, exhibits preparation, and education.



New York State teachers keep abreast of science for the classroom. One of a series of Teacher Workshops in this session conducted by the Associate Curator of Entomology.

FILM PROGRAM

A summer film program drew 400 people to five different showings of natural science films.

LOAN SERVICE

A total of 202 loan sets of Museum specimens were circulated throughout the State. This represents approximately a 25 percent increase over the previous year and a 100 percent increase over 1960-61 when the program was started. These loan kits contain geological specimens, fossils, and Indian artifacts.

RELATED ACTIVITIES

Sales Desk

The volume of sales for the year, \$5,479, showed a goodly increase over the previous year, and the success of this venture warranted the hiring of a part-time attendant from March through June. While gratifying, this increase in sales volume has posed certain problems of space (storage and display), bookkeeping and inventory taking, and selection of appropriate items, which are yet to be fully solved. As they arise, however, such problems are met and coped with by the staff with good will and considerable ingenuity. Items sold included dinosaur models (3,757), books and pamphlets (2,965), mineral kits (1,050), mastodon, brontosaurus, and beadcraft kits (824), gemstone kits (415), colored slides (368), fossil kits (179), assorted card games (101), geology tools (picks, etc.) (80), and bird records (14).

Conferences and Meetings

Throughout the year, whenever time permitted, members of the staff visited other museums, attended conferences, and participated in seminars in order to keep abreast of developments in museum education and to continue the pursuit of excellence in their chosen field.

MUSEUM LIBRARY

Service to the increased staff grew as more members were involved in writing and the preparation of new exhibits. The Library's work volume increased greatly: review and notification of publications, creation and maintenance of mailing-list file, checking of literature references in manuscripts, and proofreading of papers. The

publication of the *Geologic Map of New York, 1961*, particularly, required a large amount of correspondence.

Progress was made in the cataloging and filing of items for the Museum Library reprint and pamphlet file. The card catalog of books was checked for accuracy and corrected on a current basis. The file of U.S. Geological Survey maps (geologic and mineral resources) was completed.

Several new publications exchanges were initiated; 50 percent of these were with foreign institutions.

Cooperation was extended to the U.S. Geological Survey Library, the U.S. Geological Survey offices in Albany, and the geological surveys, libraries, universities, and museums of other States. This was additional to the service rendered to New York State Departments of Commerce, Conservation, Health, Public Works, and the Executive Department.

The following tabulated information indicates the nature and quantity of Museum Library services:

Accessions	3,495	
Transfers to State Library, Gifts and Exchange	1,000	(approx.)
Mailing list additions.....	360	
Recommendations of staff to State Library (for purchase)	125	(approx.)
Museum publications to journals for review...	48	
Interlibrary loans and photocopies.....	45	
New exchanges established.....	21	
New books received: (gift, 7; purchase, 11)...	18	
Honoraria reports received.....	9	

PHOTOGRAPHY

A total of 116 approved requisitions required taking 522 black and white photographs, processing 1,033 negatives from field photographs, and making 2,174 prints and enlargements. In addition, 88 projection slides were prepared, 174 color photographs were taken, and 103 special enlargements were made.

Requests for photographic services by the Department included: Commissioner meeting with the Chairman, Australian Broadcasting Commission; farewell party for State Librarian; Board of Regents proceedings; personnel retirement ceremonies; college students using State Library facilities; and various sessions of Convocation.

Publications

The major publication achievement of the year was the *Geologic Map of New York, 1961*, consisting of five colored maps, a large sheet of illustrations, and 42 pages of descriptive text which were enclosed between decorative covers and fastened by a spiral wire binder. Two numbers of the Map and Chart Series, the *124th Annual Report of the New York State Museum and Science Service*, a special report (of the Commissioner's Committee on Museum Resources), and one Educational Leaflet also were printed for a total of 150 pages. Three additional Educational Leaflets and a guide to museum services for teachers, comprising 120 pages were multilithed. A newsletter for geologists and others interested in the field was initiated; two numbers totaling 24 pages were issued. Ten members of the staff produced approximately 80 pages of articles, papers, and abstracts which were published in books, scientific journals, and other publications.

At the close of the year, six manuscripts were in press (one for a period of nearly two years).

PUBLICATIONS

State Museum and Science Service

- 1962 Report of the Commissioner's Committee on Museum Resources. 5 figs. 9 tab. 1 chart, 1 map. 61pp.
- 1962 The Empire State Geogram. Triannual Newsletter of the Geological Survey. 1 illus. Vol. 1, No. 1, Fall, 1962. 12pp.
- 1963 The Empire State Geogram. Triannual Newsletter of the Geological Survey. 2 illus. Vol. 1, No. 2, Winter, 1963. 12pp.
- 1963 124th Annual Report of the New York State Museum and Science Service, July 1, 1961 — June 30, 1962. N.Y. State Mus. & Sci. Serv. Bull. No. 393. 57pp.
- 1963 Teacher's Guide: Visiting the State Museum. 11pp.

Broughton, J. G. & others

- 1962 Geologic Map of New York, 1961; including the Niagara, Finger Lakes, Hudson-Mohawk, Adirondack, and Lower Hudson sheets and descriptive text, entitled *The Geology of New York State*. Scale 1:250,000 or approximately 1 inch = 4 miles

Darcy, C. M.

1962 Conservation. Educational Leaflet Series No. 15. 60pp.

Davis, J. F.

1962 Field guide to the central portion of the Southern Adirondacks. Educational Leaflet Series No. 12. 34pp.

Drumm, Judith

1962 Iroquois culture. Educational Leaflet Series No. 5. 3 illus. 14pp.

1963 Mammoths and mastodons: ice age elephants of New York. Educational Leaflet Series No. 13. 31pp.

Fisher, D. W.

1962 Correlation of the Cambrian rocks in New York State. Map and Chart Series No. 2

1962 Correlation of the Ordovician rocks in New York State. Map and Chart Series No. 3

In Outside Media

Connola, D. P. & Wixson, E. C.

1963 Effects of soil and other environmental conditions on white pine weevil attack in New York. Jour. For. 61(6):447-448

Fenton, W. N.

1962 This island, the world on the turtle's back. Jour. Amer. Folklore, Vol. 72, (Oct.-Dec.), No. 298: pp. 283-300

Jamnback, H.

1962 An eclectic method of testing the effectiveness of chemicals in killing blackfly larvae (Simuliidae: Diptera). Mosq. News 22(4): 384-389

& Eabry, H. H.

1962 Effects of DDT, as used in blackfly larval control, on stream arthropods. Jour. Econ. Ent. 55(5): 636-639

& Wirth, W. W.

1963 The species of *Culicoides* related to *obsoletus* (Maigen) in eastern North America (Diptera: Ceratopogonidae). Ent. Soc. Amer. 56(2): 185-198

Kreidler, W. L.

1963 Gas and oil developments in New York State for 1962. Amer. Assn. of Petroleum Geologists, v. 47, No. 6:935-939

Lewis, D. M.

1962 Airborne pollen sampling and pollen rain. (Abstr.) Pollen et Spores 4(2): 361

Ogden, E. C. & Raynor, G. S.

- 1962 Techniques of studying dispersion of airborne pollen.
(Abstr.) *Pollen et Spores* 4(2) : 368
-

- 1962 The dispersion of ragweed pollen from known sources.
(Abstr.) *Pollen et Spores* 4(2) : 373

Reilly, E. M., Jr.

- 1963 The swift and swallows of New York. *The Conservationist*,
v. 17, No. 5 (April-May), pp. 21-26. N.Y. State Conservation Department

Ritchie, W. A.

- 1962 Northeastern cross-ties with the Arctic. In *Prehistoric Cultural Relations between the Arctic and Temporal Zones of North America*. Arctic Institute of North America, Tech. Paper No. 11, pp. 96-99
-

- 1936 Archaeology: Western hemisphere. *Encyclopaedia Britannica Book of the Year* (1962), pp. 35-36

Smith, S. J.

- 1962 Purple loosestrife — weed or beauty. *The Conservationist*,
v. 17, No. 2 (Oct.-Nov.), p. 32. N.Y. State Conservation Department

Appendix A

1963 GRADUATE STUDENT HONORARIA RECIPIENTS

Anthropology

* JACOBSEN, JEROME — Columbia University	
Archeology of western Staten Island.....	\$ 600
WIMBERLEY, HICKMAN H. — Cornell University	
Relationship between kinship terminology and social classification	360

Botany

HELLERMAN, JOAN — Rutgers University	
Correlate the fossil diatom floras with pollen profiles determined from some core samples in Mohonk Lake Strontium isotopes in metamorphic rocks.....	480

Geology

ANDERSON, EDWIN J. — Brown University	
Study of population dynamics of <i>Gypidula coeyman-</i> <i>ensis</i> in the Helderberg limestones of New York State	360
* CARLUCCIO, LEEDS M. — Cornell University	
Study of Devonian "fern" <i>Archaeopteris</i>	168
KIRCHGASSER, WILLIAM — Cornell University	
Paleontology and stratigraphic relations of concretions and limestones of Upper Devonian Cashaqua formation	360
* MATTEN, LAWRENCE C. — Cornell University	
Study of portion of lower Upper Devonian flora.....	168
SENECHAL, RONALD G. — Rensselaer Polytechnic Institute	
Strontium isotopes in metamorphic rocks.....	480
STREET, JAMES S. — Syracuse University	
Factors controlling drift constitution in Tug Hill region of New York State.....	720
TURNER, BRIAN B. — Yale University	
Mapping northern half of Bolton quadrangle.....	720

Zoology

FISHER, ROBERT L. — Cornell University	
Ecology and life history of the red-backed mouse....	360

\$ 4,776

* Renewal.

Appendix B

Conferences and professional meetings in which the Museum and Science Service staff participated:

- American Academy of Allergy, annual meeting, Montreal, Can. — Ogden
- American Anthropological Association, annual meeting, Chicago, Ill., board meeting, Ann Arbor, Mich., Central States Branch, Detroit, Mich. — Fenton
- American Association for the Advancement of Science, annual meeting, Philadelphia, Pa. — Darcy, Stone
- American Association of Museums, annual meeting, Seattle, Wash. — Fenton
- American Ceramics Society, Eastern N.Y.S. annual meeting, Herkimer, N.Y. — Broughton
- American Geophysical Union, Washington, D.C. — Isachsen
- American Indian-Ethnohistoric-Iroquois Conference, Albany, N.Y. — Darcy, Drumm, Fenton, Funk, Gillette, Stauch, Stone
- American Mosquito Control Association, annual meeting, Atlantic City, N.J. — Collins, Jamnback
- American Ornithologists' Union, annual meeting, Salt Lake City, Utah — Palmer
- Appalachian Basin Subcommittee on Atomic Waste Disposal, Pittsburgh, Pa. — Broughton
- Association of American State Geologists, annual meeting, Morgantown, W. Va. — Broughton
- Commissioner's Committee on Museum Resources, New York City — Fenton
- Commissioner's State Conference, Diamond Point, N.Y. — Fenton
- Conservation Education Association Meetings, Stevens Point and Eagle River, Wis. — Darcy
- Cornell University, Biological Field Station, Bridgeport, and Teacher Workshops, Ithaca, N.Y. — Reilly
- Directors of Systematic Collections, 7th Conference, Pittsburgh, Pa. — Fenton
- Eastern Federation of Mineralogical and Lapidary Societies, annual meeting (13th), Lake Placid, N.Y. — Borst, Broughton, Isachsen
- Eastern New York Botanical Club, Albany, N.Y. — Lewis
- Empire State Sand, Gravel and Ready-Mix Association, meetings at Massena, Garden City, and Troy, N.Y. — Broughton, Davis
- Engineers' Society of Western Pennsylvania, annual meeting, Bradford, Pa. — Van Tyne
- Entomological Society of America, Eastern Branch, annual meeting, Philadelphia, Pa. — Collins

- First World Conference on National Parks, Seattle, Wash.
— Cahalane
- Geological Society of America, annual meeting, Houston, Tex.
— Broughton
- International Congress for Microbiology, Montreal, Can.—Connola
- International Congress of Anthropological and Ethnological Sciences (ICAES), Prague, Czechoslovakia — Fenton
- International Council on Museums (ICOM), The Hague, Netherlands — Fenton
- Interstate Oil Compact Commission Meeting, Miami, Fla.—Kreidler
- National Association of Geology Teachers, Union College, Schenectady, N.Y. — Broughton, Davis, Isachsen, Fisher, Rickard
- New England Intercollegiate Geological Conference, Montreal, Can. — Broughton, Isachsen
- New York Academy of Medicine, Eastern States Health Education Conference, New York City — Collins
- New York State Archeological Association, annual meeting, Rochester, N.Y. — Funk, Gillette, Ritchie*
- New York State Archeological Association, Van Epps-Hartley Chapter meetings, Fonda, Claverack, and Albany, N.Y. — Gillette, Ritchie*
- New York State Association of Museums, Corning, N.Y. and New York City — Fenton
- New York State Conservation Department, Bureau of Forest Pest Control, annual meeting, Saratoga Springs, N.Y. — Collins, Connola
- New York State Geological Association, annual meeting, Binghamton, N.Y. — Borst, Broughton, Davis, Isachsen, Kreidler, Rickard, Van Tyne
- New York State Oil Producers, annual meeting, Wellsville, N.Y. — Van Tyne
- New York-Vermont Interstate Commission on Lake Champlain Basin, annual meeting, Stowe, Vt. — Davis
- Northeast Anthropological Conference, Ithaca, N.Y. — Fenton, Gillette
- Northeastern Forest Pest Council, annual meeting, Boston, Mass. — Connola
- Northeastern Forest Soils Conference, Ithaca, N.Y. — Connola
- Northeastern Mosquito Control Association, annual meeting, Waltham, Mass. — Collins
- Northeastern Weed Control Conference, annual meeting, New York City — Ogden
- Northeast Museums Conference, Philadelphia, Pa.—Darcy, Drumm
- Northern Appalachian Basin Geological Society, Warren, Pa. — Van Tyne
- Paleontological Research Institution, semiannual meeting, Ithaca, N.Y. — Rickard

* Read formal paper.

Peck Mycological Foray, Dorset, Ontario, Can. — Smith
 Science Directors Association, annual meeting, Seattle, Wash.
 — Fenton
 Science Teacher's Association of New York State, Henderson
 Harbor, N.Y. — Reilly
 Society for American Archeology, annual meeting, Boulder, Col.
 — Ritchie*
 Society for Applied Anthropology, Albany, N.Y. — Fenton
 Society of American Foresters, New York Section, annual meeting,
 Utica, N.Y. — Collins, Connala
 State College Educational Research Meetings, Albany, N.Y.—Stone
 State Natural Resources Committee for Cornell-Syracuse Univer-
 sities, Ithaca, N.Y. — Cahalane
 Texaco Research Center, Beacon, N.Y. — Ritchie*
 Third International Simuliid Conference at Algonquin Park, On-
 tario, Can. — Jamnback

Appendix C

Cooperative Work (Service): Extension program by the staff
 of State Museum and Science Service to various groups:

Adirondack Mountain Club, Schenectady Chapter — Cahalane
 Capital District Mineral Club, Inc. — Borst
 Dana Natural History Society — Fenton
 Dartmouth College — Isachsen
 Hampton Manor Community Association — Connala
 Independent Petroleum Association of America — Kreidler
 Interdepartmental Health and Hospital Council — Collins
 International Salt Company — Davis
 John Burroughs Association — Cahalane
 Massena Town Board — Jamnback
 Mohonasen High School — Fenton
 Natural Resources Committee for Cornell and Syracuse Univer-
 sities — Cahalane, Collins, Fenton
 New York State College of Agriculture Extension Service—Collins
 New York State Department of Agriculture and Markets — Kreid-
 ler, Collins
 New York State Department of Commerce — Davis, Kreidler
 New York State Department of Conservation — Collins, Connala
 New York State Department of Health — Collins
 New York State Department of Labor, Division of Industrial
 Hygiene — Borst
 New York State Police (BCI) — Gillette
 Oakland University — Fenton

* Read formal paper.

Phi Beta Kappa, Union College, Schenectady — Ritchie
 Society of Engineers of Eastern New York — Fenton
 State University of New York at Buffalo, Anthropology Club —
 Fenton
 Torrey Botanical Club — Smith
 United States Bureau of Mines — Davis, Kreidler
 Women's Club of the Schenectady Army Depot — Fenton
 World Oil Periodical — Kreidler

Appendix D

COOPERATING AGENCIES

A continuing function of the Museum and Science Service is to cooperate with agencies and organizations concerned with museum and research activities in this and other States, with the governments of the United States and Canada, with universities and industry in the discovery, analysis, and dissemination of scientific information. These contacts are frequently of reciprocal services, and they arise often out of the personal contacts of the staff and, if so listed, would measure individual participation, but they are here tabulated for the organization.

Airlangza University, Indonesia
 Albany Medical Center Hospital
 Antioch College, Cooperative Placement Program
 Brown University
 California Institute of Technology
 Canadian Department of Agriculture, Ottawa
 Capital Area School Development Association
 Dartmouth College
 Desert Research Laboratory, University of Nevada
 Eastern New York Botanical Club
 Elwood Museum
 Michigan State University
 Mohawk Hudson Council on Educational Television
 Natural History Museum, Santa Rosa, Calif.
 New York Botanical Garden
 New York State Bureau of Criminal Investigation
 New York State Department of Agriculture and Markets
 New York State Department of Conservation
 New York State Department of Health
 New York State Department of Labor
 New York State Department of Public Works
 New York Zoological Society

Rensselaer Polytechnic Institute
 Russell Sage College
 State University College of Agriculture at Cornell University
 State University of New York at Albany
 State University of New York at Buffalo
 State University College at Geneseo
 State University College of Forestry at Syracuse University
 State University College of Veterinary Medicine at Eastport
 Syracuse University
 Torrey Botanical Club
 University of Massachusetts
 University of Michigan
 University of Minnesota
 University of Tennessee
 University of Toronto
 Western New York Nuclear Service Center
 Yale University

Appendix E

PROFESSIONAL AFFILIATIONS:

Offices held by staff

Adirondack Mountain Club, Vice-President; Committee on Clean
 Trailsides and Roadsides, Chairman — Cahalane
 Alan Devoe Bird Club, President — Reilly
 American Anthropological Association, executive board — Fenton
 American Committee for International Wildlife Protection, Vice-
 Chairman — Cahalane (reelected)
 American Indian Ethnohistoric Conference, President — Fenton
 American Mosquito Control Association, Editor — Collins
 American Ornithologists' Union, Committee on Bird Protection,
 Chairman — Cahalane
 Defenders of Wildlife, Vice-President — Cahalane
 Eastern New York Botanical Club, Vice-President and Program
 Chairman, 1961-62 — Smith
 Nature Conservancy, Eastern New York Chapter, Trustee
 — Cahalane
 Rochester Museum of Arts and Sciences, Fellow — Cahalane

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NH

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75

Stratigraphy and Paleontology of the Richfield Springs and Cooperstown Quadrangles, New York

Lawrence V. Rickard

Senior Paleontologist
New York State Museum and Science Service

Donald H. Zenger

Temporary Geologist
New York State Museum and Science Service

BULLETIN NUMBER 396

NEW YORK STATE MUSEUM AND
SCIENCE SERVICE



*The University
of the State
of New York*

ALBANY, NEW YORK

*The State
Education
Department*



OCTOBER 1964

Stratigraphy and Paleontology of the Richfield Springs and Cooperstown Quadrangles, New York

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New York State Museum and Science Service

*The University
of the State
of New York*

ALBANY, NEW YORK

*The State
Education
Department*



OCTOBER 1964

The University of the State of New York

Regents of the University	<i>Years when terms expire</i>
EDGAR W. COUPER, A.B., LL.D., L.H.D., <i>Chancellor</i> , Binghamton	1968
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PLATE 1.

Geologic map of the Richfield Springs quadrangle

PLATE 2.

Geologic map of the Cooperstown quadrangle

Stratigraphy and Paleontology of the Richfield Springs and Cooperstown Quadrangles, New York

by Lawrence V. Rickard
and Donald H. Zenger*

ABSTRACT

THE RICHFIELD SPRINGS AND COOPERSTOWN 15-minute quadrangles, located in east-central New York, are underlain by a sequence of fossiliferous shales, siltstones, sandstones, conglomerates, and various limestones ranging in age from Medial Ordovician to Late Devonian. Bedrock strata dip gently southwestwardly at approximately 100 feet per mile. Important unconformities occur at the top of the Frankfort Shale (Middle Ordovician), Herkimer Sandstone (Middle Silurian), and Kalkberg Limestone (Lower Devonian). Formational pinch-outs and significant facies changes occur in the Middle and Upper Silurian and Lower Devonian.

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Introduction

THE AREA COVERED by the Richfield Springs and Cooperstown quadrangles (latitude $42^{\circ} 30'$ to $43^{\circ} 00'$ north; longitude $74^{\circ} 45'$ to $75^{\circ} 00'$ west) lies at the northern edge of the Allegheny or Appalachian Plateau and includes the escarpment and lowlands leading into the Mohawk River valley to the north. It consists principally of parts of Herkimer and Otsego Counties, but also contains a small strip of Montgomery County along the eastern border and a small portion of Delaware County in the southeastern corner. Adjacent quadrangles are as follows: Little Falls, north; Canajoharie and Richmondville, east; Delhi, south; Hartwick and Winfield, west (figure 1).

The bedrock geology of the Richfield Springs quadrangle was mapped by the senior author during the summers of 1953, 1954, and 1955. Zenger mapped the bedrock geology of the Cooperstown quadrangle during the summer of 1958. Mapping of both quadrangles was done on eight $7\frac{1}{2}$ -minute maps at scales of 1 : 31,680 or 1 : 24,000, each map covering one-fourth of a quadrangle. These maps were produced by the Tennessee Valley Authority and the U.S. Geological Survey from aerial photographs taken in 1942.

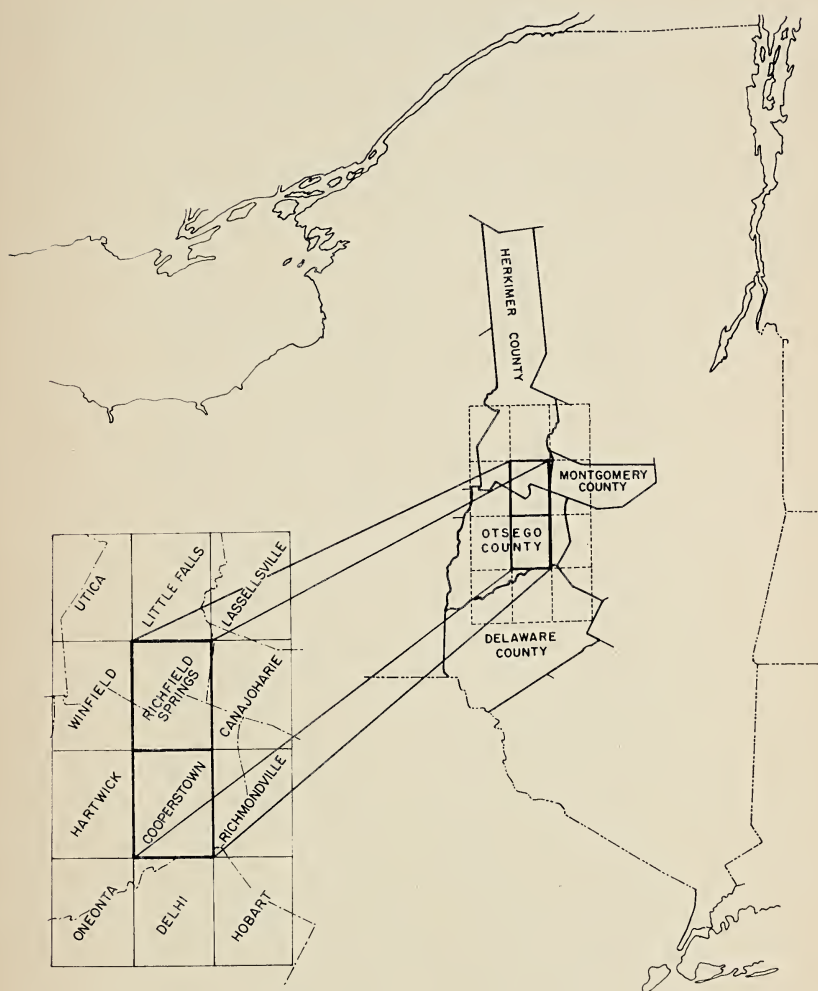


FIGURE 1. Location of the Richfield Springs and Cooperstown 15-minute quadrangles.

Acknowledgments

THE SENIOR AUTHOR wishes to express his sincere thanks to Winifred Goldring, formerly State Paleontologist, who suggested this project and under whose guidance it was initiated. He is indebted especially to several fellow workers for information and assistance in the field: William A. Oliver, Jr., U.S. Geological Survey, and the late Ralph E. Digman, Harpur College.

The junior author received financial support under the Graduate Student Honorarium program of the New York State Museum and Science Service. Advice and information for which he is grateful were obtained from Donald W. Fisher, New York State Museum and Science Service, G. Arthur Cooper, U.S. National Museum, and A. J. Boucot, California Institute of Technology. A. H. McNair, Dartmouth College, visited him in the field and offered valuable suggestions.

Physiography, Drainage, and Culture

THE AREA COVERED by the Richfield Springs and Cooperstown quadrangles may be roughly divided into three physiographic divisions — the Mohawk Valley lowlands, the Helderberg-Onondaga escarpment, and the Allegheny plateau — from north to south. Elevations in the northern lowland vary from 500 to 1,200 or 1,300 feet above sea level. Drainage is accomplished by small streams trending northward to the Mohawk River, the chief ones being the Otsquago (pronounced ot-skee-go), Ohisa-Nowadaga, and Fulmer Creeks. This division is underlain by soft shales of the Middle Ordovician. The strata are somewhat disturbed by the effects of the Little Falls normal fault, found in the adjacent Little Falls quadrangle to the north, but, in general, participate in the southwestward regional dip shown by the higher, younger rocks. No evidence for the existence of the fault plane in the Richfield Springs quadrangle has been discovered.

The Helderberg and Onondaga escarpments are here largely inseparable, forming one nearly continuous north-facing rise south of the Mohawk Valley lowlands. The escarpment varies from 500 to 600 feet in height, its crest attaining elevations of 1,700 feet in places. Thick and resistant Lower Devonian limestones of the Helderbergian Series and the Onondaga Limestone form cap rocks above much weaker Upper Silurian strata. Smaller terraces are found at lower levels where the massive Herkimer Sandstone of the Middle Silurian Clinton Group is present. The rocks of the Helderberg-Onondaga escarpment exhibit a regional dip to the southwest which averages about 100 feet per mile. Local modifications of this regional dip are most apparent from structure contours south of Deck and in the vicinity of Jordanville. Except for a few short streams descending the face of the escarpment, drainage is to the southwest. It is accomplished by such streams as Cherry Valley Creek, Shadow Brook, Hayden, and Ocquionis Creeks, most of which occupy fairly large valleys that cause deep southerly indentations in the outcrop belts of the Lower and Middle Devonian rocks.

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The southern two-thirds of the area represent the northern edge of the Appalachian Plateau. Summit elevations in this physiographic division average about 2,000 feet above sea level, but peaks above 2,200 are not uncommon. The highest elevation is that attained by Hooker Mountain, in the Cooperstown quadrangle — slightly over 2,300 feet. The generally accordant summit levels of the hills or mountains in this division may be indicative of an ancient peneplain since uplifted, dissected, and glaciated. The age and correlation of this peneplain with those recognized farther south in New York and Pennsylvania has not been determined. It would seem, however, that this is a continuation of the extensive early Tertiary Harrisburg surface so well known in that region. Drainage of the plateau is southwestward into the Susquehanna River. Several elongated lakes occupy glaciated valleys. Otsego Lake, near the center of the area, is larger and deeper than Canadarago Lake at the western border. The plateau is underlain by shales and sandstones of the Middle and Upper Devonian, variable in their resistance to weathering and erosion and hence form terraces and benches along the valley slopes. All rock units exhibit a regional dip of approximately 100 feet per mile to the southwest.

Three main highways cross the area. U.S. Route 20, the Cherry Valley Turnpike, crosses the Richfield Springs quadrangle from Cherry Valley in the east to Richfield Springs in the west. Numerous paved highways and dirt roads branching off to the north and south of Route 20 afford easy access to almost any portion of this quadrangle. U.S. Route 7 crosses the southern portion of the Cooperstown quadrangle from east to west. The main north-south highways are New York Routes 28 and 80. Road coverage of the region is entirely adequate for a thorough and detailed study of its geology. Only the higher elevations of the southern plateau are sometimes difficult to reach. Cooperstown and Richfield Springs are the largest villages. Other important centers are Milford, Schenectady, and Worcester. The remainder of the population inhabits small hamlets or numerous dairy farms throughout the area. Several divisions of the Delaware and Hudson Railroad are present in the Cooperstown quadrangle. Only a short branch of the Delaware, Lackawanna, and Western Railroad at Richfield Springs remains active in the northern quadrangle.

Geologic Column

SEDIMENTARY ROCKS of many different kinds are encountered in the Richfield Springs and Cooperstown quadrangles. Many different fossil assemblages are present, and depositional environments of numerous types are represented. Quartz pebble conglomerates, dark red sandstones with pronounced cross-bedding, hematite and bentonite beds are some of the more interesting lithologies. Faunas composed largely of eurypterids or cephalopods are present. Stromatoporoid and coral biostromes, in addition to coral bioherms (reefs), have been found. Among the more unusual depositional environments are those represented by the hematite beds and small amounts of evaporites. Indeed, the wide variety of lithologies, faunal associations, and depositional environments present, and the unconformities and facies changes which accompany them, all in these two quadrangles, suggest this area as one well suited for teaching paleontology and stratigraphy.

The geologic column of this area includes more than 30 major rock units, some with several members, ranging in age from the Medial Ordovician to the Late Devonian. The names, lithologies, thicknesses, and fossil contents of these are given in the classification below.

ORDOVICIAN SYSTEM

MOHAWKIAN SERIES, MIDDLE ORDOVICIAN

Thickness

Canajoharie-Dolgeville Shales

Fissile black shales interbedded with fine-grained dark limestones; pelagic fauna of black shale phase

Unknown

Utica Shale

Fissile to massive black shales and argillites; pelagic fauna of black shale phase

600-800 ft.

Frankfort Shale

Greenish-gray and gray shales interbedded with fine-grained cross-laminated quartzose sandstones; largely unfossiliferous; three members, lowest mapped with underlying Utica Shale; unfossiliferous
— unconformity —

500–800 ft.

SILURIAN SYSTEM

NIAGARAN SERIES, MIDDLE SILURIAN

Oneida Conglomerate

Hard, resistant quartz pebble conglomerates with black siliceous matrix interbedded with somewhat fissile greenish-gray shales; unfossiliferous

0 to 5–15 ft.

Sauquoit Formation

Typically, in the lower portion, interbedded brown siltstones and greenish-gray shales with quartz pebble conglomerates and conglomeratic sandstones near the base; and, in the upper portion, intervals of green somewhat fissile clay shales; these lithologies replaced eastwardly by cross-bedded red coarse-grained sandstone known as the Otsquago; all unfossiliferous

0 to 100–130 ft.

— ? disconformity ? —

Willowvale Shale

Green platy shales; fossiliferous
— ? disconformity ? —

0 to 25–30 ft.

Kirkland Hematite

Brownish or greenish crumbly shales interbedded with layers of hematite; poorly fossiliferous

0 to 2 ft.

Herkimer Sandstone

Coarse-grained medium to thick-bedded gray or white sandstones and some quartz pebble conglomerates; unfossiliferous
— unconformity —

0 to 12–40 ft.

CAYUGAN SERIES, UPPER SILURIAN

Vernon Shale

Dark red and green crumbly shales lacking distinct bedding planes; unfossiliferous 0 to 60–80 ft.

Brayman Shale (Syracuse-Camillus-Bertie)

In lower portion, drab-weathering dark gray thin-bedded shales and limestones of variable argillaceous and dolomitic contents; in upper portion, largely crumbly green shales; scattered evaporites; poorly fossiliferous 100–200 ft.
— ? disconformity ? —

Cobleskill Limestone

Mottled argillaceous and dolomitic limestones weathering drab yellowish-gray; poorly fossiliferous 10–12 ft.

DEVONIAN SYSTEM

HELDERBERGIAN SERIES, LOWER DEVONIAN

Chrysler Dolomite (Rondout)

Argillaceous shaly to thinly bedded dolomites; straticulate bedding; unfossiliferous 30–40 ft.

Thacher Limestone (Manlius)

Dark bluish-black fine-grained limestones; thin to medium bedded; two divisions; stromatoporoid biostrome at top; fossiliferous 30–40 ft.

Ravena Limestone (Coeymans)

Resistant dark-gray crinoidal coarse-grained massive and irregularly bedded limestones; fossiliferous; grades westwardly into the next three units listed below 90–100 ft.

Dayville Limestone (Coeymans)

Predominantly, coarse-grained gray crinoidal limestones, but contains beds of finer-grained dark blue limestone; fossiliferous 40–50 ft.

Elmwood, Clark Reservation, and Jamesville Limestones (undifferentiated, Manlius)

Dark blue or gray fine to medium-grained thin and evenly bedded limestones; stromatoporoid biostrome at top; poorly fossiliferous 0–30 ft.

Deansboro Limestone (Coeymans)

Hard, resistant coarse-grained and crinoidal gray or blue limestones with massive irregular bedding; fossiliferous

30-40 ft.

Kalkberg Limestone

Medium-grained thin to medium bedded dark blue limestones with interbedded calcareous shales and much dark colored chert in beds, lenses and nodules; very fossiliferous

15-50 ft.

— unconformity —

ULSTERIAN SERIES, LOWER DEVONIAN

Oriskany Sandstone

Hard orthoquartzite

0-2 ft.

— ? disconformity ? —

Esopus Shale

Gray siliceous shales and siltstones; unfossiliferous

0-20 ft.

— ? disconformity ? —

Carlisle Center Shale

Buff-weathering calcareous and siliceous shales and siltstones

10-40 ft.

— ? disconformity ? —

Rickard Hill Limestone (Schoharie)

Arenaceous limestone

0-1 ft.

 ERIAN SERIES, MIDDLE DEVONIAN

Onondaga Limestone

At the base, massive gray coarse-grained crinoidal limestones with white-weathering chert; coral biostromes and bioherms; above, fine-grained, medium-gray limestones with shaly partings and black chert; four members; quite fossiliferous

120 ft.

Union Springs Shale

Fissile black shale with calcareous concretions and thin dark limestones near the top; pelagic fauna of black shale phase

25 ft.

Cherry Valley Limestone

Black argillaceous limestone; cephalopod fauna

5 ft.

Chittenango Shale

Jet-black fissile shale with limestone septaria and calcareous concretions; meager pelagic fauna of black shale phase

150 ft.

Otsego Shale

Dark-gray soft crumbly shale below becoming harder and sandier above; two divisions; poorly fossiliferous

260 ft.

Solsville Sandstone

Below, dark-gray or black argillaceous and somewhat fissile shales grading upward into dark gray silty and arenaceous shales; resistant brown-weathering dark-gray sandstones and very arenaceous shales at top; three divisions; fossiliferous

290 ft.

Panther Mountain Formation

Undifferentiated units of interbedded brown-weathering sandstones and arenaceous shales; fossiliferous

800 ft.

Portland Point Limestone

Arenaceous calcarenite and calcareous shales; fossiliferous

5-6 ft.

Cooperstown Shale

Bluish, arenaceous shales and fine-grained gray and brown argillaceous sandstones; fossiliferous

410 ft.

SENECAN SERIES, UPPER DEVONIAN

Gilboa Formation

Bluish-gray shales and argillaceous sandstones; fossiliferous

460 ft.

Oneonta Formation

Greenish-gray, thin-bedded, flaggy, and cross-bedded sandstones; poorly fossiliferous

200 ft.

Stratigraphy and Paleontology

ORDOVICIAN SYSTEM

MOHAWKIAN SERIES

NUMEROUS EXPOSURES of late Medial Ordovician black shales referred to the Canajoharie-Dolgeville and Utica Formations occur in the northeastern corner of the Richfield Springs quadrangle. Older rocks are not known to be exposed within the limits of the quadrangle. Black shales of the upper Utica probably also underlie several scattered areas in the northwestern portion of the quadrangle along Spoon (Spohn), Hungry Hill, and Fulmer Creeks, although exposures are much less frequent. Gray shales and sandstones assigned to the Frankfort Formation overlie the Utica black shales everywhere across the northern portion of the Richfield Springs quadrangle.

Canajoharie-Dolgeville Shales

Along the lowermost portion of Nowadaga Creek, in the vicinity of the first bridge near the northern boundary of the Richfield Springs quadrangle, fissile black shales interbedded with dark limestones are exposed. These beds appear to be the uppermost portion of the Canajoharie Shale (Ruedemann, 1912), more fully developed to the east of the quadrangle. The presence of numerous dark-colored limestone beds indicates that here the black shales of the upper Canajoharie are grading laterally into the Denmark Limestone of the Trenton Group, found to the north and west of the quadrangle. The name *Dolgeville* (Cushing, in Miller, 1909) also is applicable to these beds. Due to their very limited extent and lithological similarity to the much thicker Utica shales above, no attempt has been made to distinguish the Dolgeville beds from the Utica on the geologic map.

The Dolgeville beds consist of thin dark calcilutites, usually barren of fossils, interbedded with fissile black shales having a rather small

fauna of graptolites, inarticulate brachiopods, and trilobites. The thickness of the Dolgeville is unknown; probably less than 50 feet of beds may be referred to this unit. The Dolgeville grades upward into the overlying Utica Shale without disconformity. The contact cannot be exactly placed—the transition from Dolgeville to Utica being indicated by a change in the faunal content of the beds and a gradual decline in the number and thickness of the limestone beds.

From the lower portion of Nowadaga Creek, at and below the first bridge across the stream, Ruedemann (1925, p. 29) obtained the following fossils. He states that the presence of *Climacograptus spiniferus* and *Ulrichia bivertex* in this fauna indicates that these shales and limestones should be referred to the Dolgeville or uppermost Canajoharie.

GRAPTOLITES

Climacograptus spiniferus Ruedemann
Orthograptus quadrimucronatus (Hall)
Dicranograptus nicholsoni Hopkinson
Lasiograptus eucharis (Hall)

BRACHIOPODS

Lingula curta Conrad
Leptobolus insignia Hall
Schizocrania filosa Hall
Paucicrura rogata (Sardeson)
Sowerbyella sericeus (Sowerby)

TRILOBITES

Triarthrus eatoni (Hall)
T. becki Green
Isotelus gigas (Dekay)
Ceraurus sp.
Odontopleura cf. *crosota* (Locke)

OSTRACODES

Ulrichia bivertex (Ulrich)
Primitiella unicornia (Ulrich)
Bythocypris cylindrica (Hall)
Aparchites minutissimus var. *trentonensis* Ulrich

MISCELLANEOUS

Endoceras sp.
Lepidocoleus jamesi (Hall and Whitfield)

In the same area, Rickard collected: *Climacograptus* sp., common; *Triarthrus eatoni*, common; *Leptobolus insignis*, common; and the



FIGURE 3. Interbedded limestones and black shales, Dolgeville beds, exposed west of the northernmost bridge over Nowadaga Creek, Richfield Springs quadrangle.
Photograph by L. V. Rickard

nautiloid cephalopod *Geisonoceras tenuistriatum*. In addition, both inarticulate and articulate brachiopods, a small coiled cephalopod, and numerous ostracodes also were noted, most too poorly preserved to be identified with certainty.

Utica Shale

A large area in the northeast corner of the Richfield Springs quadrangle is underlain by black shales assigned to the Utica Formation (Vanuxem, 1842). There are many exposures of the Utica in this area, most of them located along streams or in road cuts. Additional exposures of the Utica may be found along Spoon, Hungry Hill, and Fulmer Creeks in the northwestern portion of the quadrangle.

By far the best and most complete exposure of the Utica Shale is that along Nowadaga Creek. A nearly continuous section extends from just above the first bridge over the creek upstream through the village of Newville and beyond into several tributaries to Nowadaga Creek, the chief one being Ohisa Creek. The fissile to massive shales of the Utica are exposed both in the banks and in the beds of Nowadaga Creek and its tributaries at numerous localities, many of which are indicated on the geologic map. Long sequences of monotonous similarity occur in which it is impossible to determine stratigraphic horizons without recourse to the contained faunas. Even these will provide only approximations since identical faunas extend through units of considerable thickness. In this section, the Utica Shale is estimated to be between 600 and 800 feet thick.

In his study of this long sequence of black shales, Ruedemann (1925, pp. 29-31) distinguished three faunal zones. These were named from the graptolites predominant in each, as follows, in ascending order: (1) zone of *Climacograptus typicalis*, *Orthograptus quadrimucronatus approximatus*, and *Lasiograptus eucharis*; (2) zone of *Dicranograptus nicholsoni*; and (3) zone of *Climacograptus pygmaeus* and *Orthograptus quadrimucronatus timidus*. Zone one appeared to be the thickest, extending through some 200 feet of rock. Zones two and three were reported to occur in approximately 170 and 150 to 200 feet of black shales, respectively.

The lowest Utica graptolite zone of Ruedemann outcrops along Nowadaga Creek from the first bridge over the stream southwestward to the vicinity of an old mill located about 1 mile downstream from Newville. From this zone Ruedemann (ref. cit., p. 30) reported the following species.

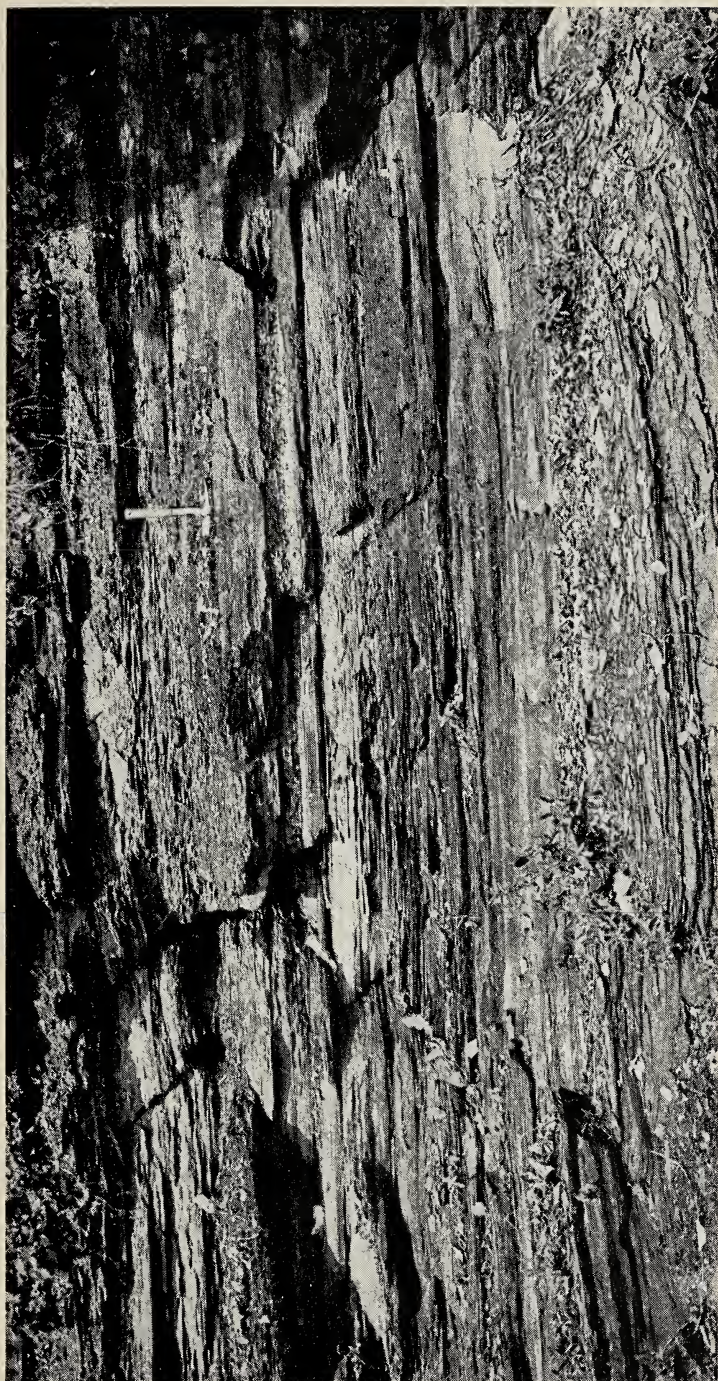


FIGURE 4. Fissile black shales assigned to the Utica Formation exposed along Nowadaga Creek, Richfield Springs quadrangle.
Photograph by L. V. Rickard

- Climacograptus typicalis* Hall, very common
Orthograptus quadrimucronatus approximatus Ruedemann, very common
Lasiograptus eucharis (Hall), very common
Leptobolus insignis Hall, common
Pterinea insueta Hall, very rare
Geisonoceras tenuistriatum (Hall), common
Triarthrus eatoni (Hall), common

Rickard collected *Climacograptus typicalis*, common, and *Triarthrus eatoni*, common, from the same interval. Unusually large specimens of *T. eatoni* were frequently encountered in the black shales exposed around the second large meander in Nowadaga Creek, just above the third bridge over the creek. Specimens of the pelecypod *Pterinea insueta* and *Geisonoceras tenuistriatum* were also obtained from this interval.

Ruedemann's *Dicranograptus nicholsoni* zone extends from a point about three-quarters of a mile below Newville upstream through the village and beyond for a short distance. From this second graptolite zone within the Utica, Ruedemann (ref. cit., p. 30) collected the following fossils.

- Dicranograptus nicholsoni* Hopkinson, very common
Climacograptus typicalis Hall, common
Orthograptus quadrimucronatus approximatus Ruedemann, rare
Leptograptus annectans Walcott, rare
Lasiograptus eucharis (Hall), common
Triarthrus eatoni (Hall)

From two exposures located about $\frac{1}{2}$ to $\frac{3}{4}$ mile below Newville, Rickard obtained numerous specimens of *Dicranograptus nicholsoni* and *Climacograptus typicalis*. From exposures located around a small meander just below Newville, *Geisonoceras tenuistriatum*, *Triarthrus eatoni*, and the pelecypod *Modiolopsis modiolaris* were collected. Just above Newville a few specimens of *Leptograptus annectans* were found associated with *Geisonoceras tenuistriatum*, *Triarthrus eatoni*, *Leptobolus insignis*, and *Climacograptus* sp.

The third Utica graptolite zone, according to Ruedemann (ref. cit., p. 31), is characterized by the following species.

- Climacograptus pygmaeus* Ruedemann, very common
C. typicalis Hall, common
Glossograptus quadrimucronatus timidus Ruedemann, common
Corynoides ultimus Ruedemann, very common

Cyathodictya pyriformis Ruedemann, rare

Leptobolus insignis Hall, common

Triarthrus eatoni (Hall)

This zone extends from the top of the *Dicranograptus nicholsoni* zone located just above Newville to the base of the overlying Frankfort shales and sandstones. The upper boundary with the Frankfort is quite indistinct. The black shales of the Utica are very gradually replaced upward by the greenish-gray shales of the lower Frankfort. Search for fossils along Nowadaga and Ohisa Creeks above Newville proved unsuccessful.

Exposures of the Utica Shale, exclusive of those along Nowadaga and Ohisa Creeks, are numerous. Their stratigraphic position within the Utica can be ascertained only by noting their position on the map and by identifying the fossils collected from them. Some of the more continuous ones are found along the small southern tributary to Nowadaga Creek, just east of Newville, along a northward tributary located between Johnnycake Street Road and Route 167, about 2 miles west of Newville, and in several streams north, west, and southwest of Wrights Corners near the northern boundary of the quadrangle.

From an exposure on a slight bend in Route 167, 0.4 mile north of Wrights Corners, Rickard obtained *Climacograptus typicalis*, *Dicranograptus nicholsoni*, and *Triarthrus eatoni*. *D. nicholsoni* was also obtained from a roadside pit (elevation, 760 feet) along a dirt road west of Nowadaga Creek at a point about 0.2 mile south of the northern boundary of the quadrangle. Fossils were collected at a point 1.5 miles west of Newville from the bed of a small brook west of the dirt road at elevation 780 feet. *Climacograptus pygmaeus*, *C. typicalis*, and *Leptobolus insignis* were found here.

Frankfort Shale

The youngest rocks of Ordovician age present in the Richfield Springs quadrangle are the shales and sandstones of the Frankfort Formation (Vanuxem, 1840). The Frankfort consists of greenish-gray and gray shales interbedded with fine-grained, quartzose sandstones which are usually cross laminated and thinly bedded, and which weather to a tan or buff color. The thickness of the formation apparently varies from less than 500 feet to more than 800 feet within the quadrangle. Much of this variation is probably due to the unconformity between the Frankfort and the overlying Oneida Conglomerate of the Silurian. East of Van Hornesville, the Clinton Group

rapidly diminishes in thickness and eventually disappears. In the same area, the Frankfort experiences a rapid increase in thickness.

Somewhat less than 500 feet of Frankfort are present in the hillside south of Fulmer Creek; between Deck and Smith Corners, an estimated 500 feet of Frankfort are present. Along Otsquago Creek the Frankfort seems to be thicker, increasing to approximately 600 feet here. Farther east, near the eastern border of the quadrangle, over 800 feet of Frankfort appears to be present. All estimates of the thickness of the Frankfort given above include increases due to the dip of the formation.

The Frankfort shales and sandstones underlie most of the northwestern portion of the quadrangle and occupy a southeastwardly trending belt in the northeastern part of the area. Extensive exposures of the Frankfort beds occur along Otsquago, Ohisa, Spoon, and Fulmer Creeks, their tributaries, and the uppermost portions of Nowadaga Creek. Various isolated exposures may be found along smaller streams and in roadcuts throughout the broad area of Frankfort outcrop. Many of these are indicated on the geologic map.

In his report on the geology of the Utica quadrangle, Kay (1953, pp. 64-67) subdivided the Frankfort into three members, based largely on upward changes in the lithology of the formation. The lower or Harter Member, according to Kay (ref. cit., p. 64), "consists of greenish-gray, laminated claystone, grading rather imperceptibly into the black shale of the Utica formation below. The shale weathers and breaks into small, conchoidally fractured chips, in contrast to the more platy, larger fragments of the Utica. . . ." It is about 100 feet thick in the Utica quadrangle and was included by Kay with the underlying Utica Shale on his geologic map. A similar lithologic unit of approximately the same thickness was found to occur at the base of the Frankfort in the Richfield Springs area. As in the Utica quadrangle, the Harter Member has been included in the area mapped as Utica Shale because of the difficulty of separating it from the underlying black shales.

The Utica-Frankfort boundary indicated on the geologic map of this area has been drawn at the base of the first sandstone bed encountered in each section when proceeding upward from the black shale of the Utica Formation. This horizon probably corresponds to the base of Kay's second Frankfort member, the Hasenclever (ref. cit., pp. 64, 66). The Hasenclever, described by Kay as "composed of finely cross-laminated, buff-weathering, thin-bedded fine sandstones and interbedded greenish shales," is approximately 40 feet thick in the Utica quadrangle.

The third division of the Frankfort was named the Moyer Member by Kay (ref. cit., p. 66) from the fine exposures of the upper Frankfort along Moyer Creek, southwest of Frankfort. This member, according to Kay, consists "principally of gray, somewhat arenaceous shale, with beds to a foot thick of finely cross-laminated sandstone. . . ." It is the thickest member of the Frankfort in the Utica quadrangle — approximately 400 feet. Lithologies similar to the Hasenclever and Moyer Members occur within the Frankfort of the Richfield Springs quadrangle, but their thicknesses and extents in this area are unknown.

Even after extended search, few fossils have been found in the Frankfort shales and sandstones of the Richfield Springs quadrangle. Ruedemann (1925, pp. 28, 55) collected the following species from the ravine of Spoon Creek, located near the northern boundary of the quadrangle about 2 miles east of Fulmer Creek.

Climacograptus pygmaeus Ruedemann

Leptobolus insignis Hall

Serpulites crassimarginalis Ruedemann

Geisonoceras sp.

Small unidentifiable pelecypod

This small collection is the only reported occurrence of Frankfort fossils from the Richfield Springs quadrangle. These were probably obtained from the lower or Harter Member of the formation.

SILURIAN SYSTEM

NIAGARAN SERIES

THE NIAGARAN SERIES of the Lower and Middle Silurian contains three groups which are, in ascending order, the Medina, the Clinton, and the Lockport. These three are well developed in central and western New York, but only the middle or Clinton Group is present in the Richfield Springs quadrangle. This group outcrops along the base of a north-facing escarpment extending northwestward from the eastern border to the middle of the quadrangle, where it bends westward to the western edge of the quadrangle. The group is exposed in numerous streams descending the face of this escarpment across the quadrangle which afford many excellent sections for study and

correlation. Contacts of the Clinton Group with the underlying and overlying rocks in this area are unconformable. Physical evidence of these erosive periods has been observed at the top and bottom of the group in several exposures. The thickness of the group decreases eastwardly across the quadrangle to its disappearance near the eastern border. This permits the overlying Upper Silurian Cayugan Series to rest unconformably upon the Middle Ordovician in the hillside, south of the Dugway Gorge at Salt Springville.

The total thickness of the Clinton Group has been measured or estimated at a number of exposures, listed below from west to east across the quadrangle.

Section	Approximate Thickness
*Flat Creek	200 ft.
*Road south of Edicks	200 ft.
*Stream south-southeast of Edicks	180 ft.
Road south of Paines Hollow	190 ft.
*Stream south of Deck	150 ft.
Hillside to south midway between Deck and Smith Corners	100-120 ft.
Road south of Smith Corners	110-160 ft.
*Ohisa Creek	130 ft.
Road 2.1 miles west of Starkville	60-80 ft.
*Otsquago Creek at Van Hornesville	140 ft.
Road 1.7 miles south-southwest of Starkville	75 ft.
Stream 0.6 mile north of Willse Four Corners	70 ft.
*Stream 0.5 mile north of Willse Four Corners	70 ft.
*Stream 1.2 miles north of Salt Springville	30-50 ft.
*Stream 0.8 mile west of Salt Springville	20-30 ft.
*Stream 0.8 mile southwest of Salt Springville	absent

The effect of the unconformable upper contact of the Clinton Group on its total thickness is apparent from the tabulation given above. Those sections marked with an asterisk (*) are most continuous or complete.

Six stratigraphic units may be distinguished within the Clinton Group in the Richfield Springs quadrangle. These are, in ascending order, the Oneida Conglomerate, the Sauquoit Formation, which contains an eastwardly thickening cross-bedded red sandstone facies known as the Otsquago, the Willowvale Shale, the Kirkland Hematite, and the Herkimer Sandstone. With the exception of the Westmoreland Hematite found at the base of the Willowvale Shale and the Otsquago facies of the Sauquoit, this includes all the units recognized by Gillette (1947) in his easternmost section of the Clinton Group at Willowvale in the Rome quadrangle. It includes all the

units recognized by Dale (1953) in the same quadrangle and by Grossman (in Kay, 1953) in the Utica quadrangle.

In his extensive and detailed study of the Clinton Group of central and western New York, Gillette (1947) distinguished five ostracode zones within the group. These faunal zones are very important for determination of the age and correlation of the Clinton units. Named from a predominate ostracode in each, these are, in ascending order: (1) the *Zygobolba excavata* and (2) the *Z. decora* zones of the Lower Clinton; (3) the *Mastigobolbina lata* zone of the Middle Clinton; (4) the *M. typus* and (5) the *Paraechmina spinosa* zones of the Upper Clinton.

Oneida Conglomerate

The Lower Clinton *Zygobolba decora* zone apparently is represented in the Richfield Springs quadrangle by the Oneida Conglomerate (Vanuxem, 1842), although ostracodes or any other type of fossils have not been obtained from the Oneida in this area. It is possible that a portion of the Middle Clinton *Mastigobolbina lata* zone also is represented since the Oneida probably becomes younger to the east. The Oneida is a fine example of a so-called "basal conglomerate" produced as the initial deposit of a transgressing sea, in this case an eastwardly advancing one. In this area, the Oneida consists of hard, resistant quartz pebble conglomerate usually having a black siliceous matrix interbedded with somewhat fissile greenish-gray shales. Pyrite is quite common in some beds within the lowermost portion of the formation.

Determination of the thickness of the Oneida Conglomerate becomes increasingly more difficult eastward from the type area near Clinton, Oneida County, because of the introduction of conglomerates of similar lithology in the basal portion of the overlying Sauquoit. Fossils are apparently lacking along this horizon and thus offer no solution to the problem. Across the Richfield Springs quadrangle, thicknesses from 5 feet to as much as 15 feet could be referred to the Oneida. At the base of the Sauquoit, in the sections along Ohisa and Otsquago Creeks, a 1-2 foot quartz pebble conglomerate with a white matrix and phosphate nodules overlies a layer of green platy shale. Immediately below this horizon, 6 feet of conglomerates and green shales have been referred to the Oneida. These conglomerates have a dark matrix, lack phosphate nodules, and unconformably overlie the Frankfort Shale.

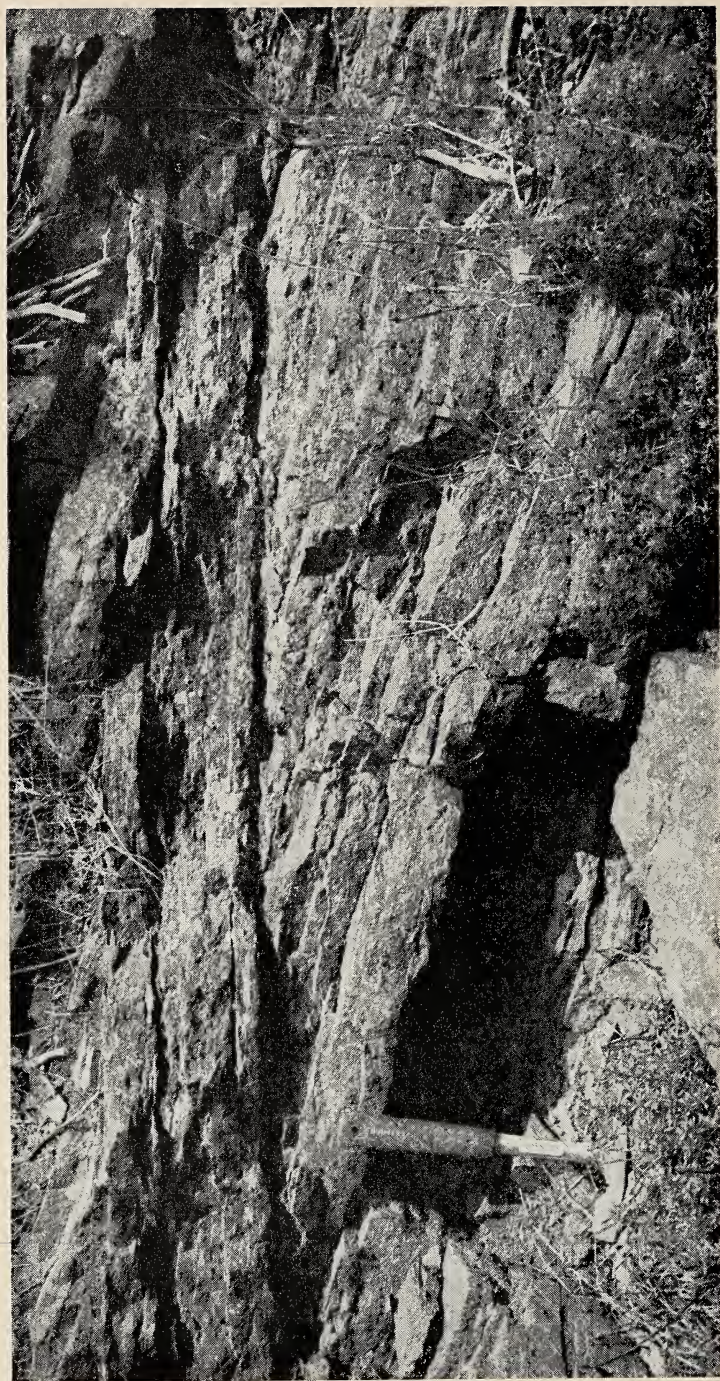


FIGURE 5. Cross-bedding in the Oneida Conglomerate exposed at elevation 1,284 along paved road 1.5 miles north-northeast of Van Hornesville, Richfield Springs quadrangle. Photograph by L. V. Rickard

At Deck, the Oneida is exposed in the stream on the north side of Route 168. It is at least 6 feet thick, the beds next above being covered. In the stream south-southeast of Edicks, just east of an abandoned railroad bed, and along Flat Creek, the upper contact is much more difficult to establish. Some 6 to 15 feet of quartz-pebble conglomerates interbedded with green platy shales could be considered part of this formation.

No difficulty is encountered in establishing the basal contact of the Oneida. The striking contrast in lithology between the gray shales of the Frankfort and the conglomerate of the Oneida makes this horizon easily recognizable. Pyrite is quite commonly encountered along the contact. Truncation of bedding in the Frankfort is not apparent as the exposures are usually of limited extent, nor is any great amount of erosive relief to be seen. Nevertheless, the unconformable nature of this horizon is readily demonstrated by the absence of the entire Medina Group.

Sauquoit Formation

The Middle Clinton *Mastigobolbina lata* zone is represented in the Richfield Springs quadrangle by the shales and sandstones of the Sauquoit Formation (Chadwick, 1918). Essentially three types of lithologies occur in the Sauquoit. These are interbedded, recurring at successive horizons upward through Sauquoit sections, and interfinger laterally between exposures, replacing one another along stratigraphically equivalent horizons.

In the more westward exposures of the Sauquoit, particularly those west of the Richfield Springs quadrangle, intervals of interbedded gray or brown siltstones or sandstones and greenish-gray shales occur within the formation. Quartz pebble conglomerates and conglomeratic sandstones with phosphate nodules or clay galls are not infrequently encountered. This lithology appears to alternate with one composed largely of green, somewhat fissile clay shales and thin sandstones. The former lithology predominates in the lower Sauquoit and the latter in the upper portion, but both may occur at any level within the unit. Neither appears to have fossils in any abundance.

To the east, and especially within the Richfield Springs quadrangle, the lithologies described above occur in the Sauquoit but are replaced eastwardly across the quadrangle by a third type. This is the red, green, and black thick-bedded sandstone, commonly cross-bedded on a very impressive scale, known as the Otsquago (Chadwick, 1918).

The Otsquago replaces more and more of the "typical" Sauquoit to the east. At and beyond Edicks, in the central and eastern portions of the quadrangle, the Otsquago predominates, exposed in stream beds and many hillside outcrops. Along the extreme eastern border of the quadrangle, all the Sauquoit consists of this black, hematitic, cross-bedded sandstone.

The difficulty of separating the Sauquoit from the underlying Oneida has already been discussed. Problems of a similar nature are also encountered with the upper boundary of the formation. West of the Richfield Springs quadrangle, the presence of the Westmoreland Hematite between the Sauquoit and the overlying Willowvale of the Upper Clinton aids considerably in the identification of the upper contact. Within the area discussed in this report, the Westmoreland is absent. The greenish-gray fissile shale of the Willowvale is practically indistinguishable from the green clay shale of the upper Sauquoit. The absence of the Westmoreland iron ore would seem to indicate that this contact was unconformable, but physical evidence for such an interpretation has not been seen in the field. Only fossils seem to present a possible solution. The Willowvale is occasionally fossiliferous; the underlying Sauquoit has yet to produce a fauna from exposures in this area. If a Sauquoit fauna should be discovered, however, it should possess the diagnostic species of the Middle Clinton *Mastigobolbina lata* zone. The overlying Willowvale lies within the *M. typus* zone of the Upper Clinton.

The thickness of the Sauquoit shales and sandstones varies across the quadrangle, due principally to the effects of the post-Clinton and pre-Cayugan episode of erosion. West of Deck, the Sauquoit maintains a thickness of about 110 to 130 feet. Just east of Deck, the higher formations of the Clinton (Willowvale, Kirkland, and Herkimer) are truncated by the post-Clinton unconformity. In the hillside, approximately midway between Deck and Smith Corners, the total estimated thickness for the Clinton Group is only 100-120 feet. It is probable that here the Upper Silurian Cayugan Series rests upon the Sauquoit rather than the Upper Clinton. Farther east, beyond Smith Corners and in the Ohisa Creek section, the unconformity rises stratigraphically. The Willowvale Shale and Kirkland Hematite reappear at the top of a nearly complete section exhibiting approximately 100 feet of Sauquoit. In the hillside, 2.1 miles west of Starkville, the Upper Clinton units appear to be absent once more. The total thickness of the Clinton Group is less than 100 feet, and no evidence for the presence of the Upper Clinton units was seen in the field. In the section along Otsquago Creek at Van Hornesville, the unconformity again rises. The Willowvale, Kirkland, and Her-

kimer all reappear at the top of the Clinton Group in this exposure. Nearly 100 feet of Sauquoit were measured here. Farther east, to the eastern border of the quadrangle, the Upper Clinton is absent, and the total thickness of the Clinton Group rapidly diminishes. In the sections east of Van Hornesville, only the Oneida and a decreasing amount of the Sauquoit are present. The Cayuga Series rests upon 70 feet of Oneida and Otsquago in the stream exposures north of Willse Four Corners. Only 30–50 feet are known along the stream 1.2 miles north of Salt Springville. West and southwest of Salt Springville, in the Dugway Gorge vicinity, the Clinton Group disappears entirely. The manner of its truncation from above, by the post-Clinton unconformity and the geographic distribution of the exposures exhibiting this truncation, indicates that it occurs not only eastwardly, but also toward the south. The Salt Springville exposures lie on a more southerly latitude than do those of any other Clinton area within the Richfield Springs quadrangle.

Willowvale Shale

Overlying the Sauquoit shales and sandstones, possibly disconformably due to the absence of the Westmoreland Hematite, is a rather consistent thickness of green, platy shales bearing fossils. This unit appears only in those exposures of the Clinton Group containing Upper Clinton formations. It is known as the Willowvale Shale (Gillette, 1947) and contains the Upper Clinton *Mastigobolbina typus* zone. The Willowvale is difficult to separate from the underlying greenish shales of the upper Sauquoit, but contrasts strongly with the Kirkland Hematite above (or the massive Herkimer Sandstone where the hematite is absent).

In the Richfield Springs quadrangle, the Willowvale Shale occurs sporadically as do all the Upper Clinton units because of the effects of the post-Clinton unconformity, previously described. The Willowvale enters the quadrangle from the west and is partially exposed on Flat Creek. Here, $11\frac{1}{2}$ feet of green and brown shales, presumably Willowvale, are exposed at the base of the high waterfall, just north of the paved highway. This shale is overlain by 10 feet of interbedded green shales and thin brown sandstones. No hematite referable to the Kirkland occurs in this sequence. The interbedded shales and sandstones are directly overlain by the white sandstones of the Herkimer which form the cap rock of the waterfall. An identical sequence of lithologies occurs at the waterfall in the stream south of Deck.

In the section between Deck and Flat Creek, that along the stream south-southeast of Edicks and just east of an abandoned railroad, a slightly different sequence is encountered. Here, there is no unit of interbedded shales and sandstones. The Kirkland ore is present, overlying 16 feet (aneroid) of undoubted green, crumbly Willowvale Shale and overlain itself by the medium to thick-bedded white sandstones of the Herkimer, again forming the cap rock of a waterfall. Similar sequences are encountered in the sections along Ohisa Creek and along Otsquago Creek at Van Hornesville. In both these exposures, the Kirkland Hematite is present, overlying about 25 feet of shales referred to the Willowvale. The interbedded shale and sandstone unit is absent in these sections.

It is not known whether these interbedded shales and sandstones should be referred to the Willowvale or to the Herkimer. The absence of the Kirkland Hematite in sections containing this interbedded unit and the lack of fossils in it complicates the problem. The possibility that these interbedded shales and sandstones could be considered as Kirkland in age should not be overlooked. It is interesting to note that, where the Kirkland occurs, the interbedded unit is absent and vice versa. It seems best to consider this unit a portion of the Willowvale. Similar interbedded shales and sandstones of unpredictable occurrence have been reported from the upper Willowvale in the Utica quadrangle by Grossman (in Kay, 1953, p. 69). Farther west, the upper Willowvale contains "dolomitic sandy lentils" reported by Dale (1953, p. 60). Several thin, hard sandstone beds were seen by the writer in the Willowvale at Van Hornesville. Within the Richfield Springs quadrangle, the combined thickness of the interbedded unit and the typical green shale below found at Flat Creek and Deck nearly matches that of the Willowvale Shale below the Kirkland encountered in the exposures south of Edicks and along Ohisa and Otsquago Creeks. This interval is approximately 25-30 feet, which compares favorably with the 30 feet of Willowvale reported by Grossman (in Kay, 1953, p. 69) for the Utica quadrangle, the 28½ feet found by Dale (1953, p. 60) in the Rome quadrangle, and the 22 feet given by Gillette (1947, p. 94) for the type Willowvale.

Of all the Clinton formations found within the Richfield Springs quadrangle, only the Willowvale Shale has produced a fauna of reasonable size. Poorly preserved ostracodes, brachiopods and trilobites were noted in the Willowvale Shale exposed at Van Hornesville. Fucoids are present in the thin, hard layers of the shale at this locality. Willowvale fossils were also obtained from the Ohisa Creek exposure and from a roadside exposure below the Herkimer, 0.6 mile south of Paines Hollow. The fauna of the Willowvale Shale in this quad-

"Dalmanella" elegantula (Dalman)
Chonetes cornutus (Hall)
Pholidops squamiformis (Hall)
Lingula perovata (Hall)
"Camarotoechia" neglecta (Hall)
Schuchertella subplana (Conrad)
Stropheodonta corrugata (Conrad)
Eocoelia sulcata (Prouty)
Calymene niagarensis Hall
Liocalymene clintoni (Vanuxem)
Mastigobolbina typus Ulrich and Bassler
Zygosella cf. *vallata* Ulrich and Bassler
Plethobolbina typicalis Ulrich and Bassler
Tentaculites sp.

Kirkland Hematite

The name *Kirkland* was proposed by Chadwick (1918) to replace the term "red flux iron ore" by which this unit was known to earlier workers. Gillette (1947) adopted the new name, but both Dale (1953) and Grossman (in Kay, 1953) in later works have not seen fit to do so. Dale includes both the Westmoreland and Kirkland Hematites in the Willowvale. Grossman, although he includes the Westmoreland in the Willowvale, associates the Kirkland with other iron ore zones found in the Herkimer Sandstone. Since the Westmoreland and Kirkland are the only hematites extensively mined in former years from the eastern portion of the Clinton Group, the use of these names for specific iron ore horizons seems proper. In addition, such terms as "red flux," "oolitic," "sub-oolitic," formerly used, although somewhat suggestive of lithology, are more confusing than clarifying since the exact definitions of these terms vary from one geologist to another. Hence, their usage does not seem desirable and should be suppressed in favor of the more specific geographic names.

The Kirkland Hematite of the Richfield Springs quadrangle is exposed in the sections along the stream south-southeast of Edicks and along Ohisa and Otsquago Creeks. It is 6 to 12 inches thick in the Edicks exposure and 18 inches along Ohisa Creek. In the former section, it is overlain by the Herkimer Sandstone; in the latter, a disconformity with the Upper Silurian Brayman Shale is exhibited. The Kirkland, at the sharp bend in Route 80 in Van Hornesville, consists

of about 2 feet of brownish crumbly shale containing two hematite beds. It is here overlain by 12 feet of Herkimer Sandstone.

Although the Kirkland contains numerous crinoid columnals at many exposures, its fauna is a very small one. Gillette (1947) includes the Kirkland in the Upper Clinton *Paraechmina spinosa* zone, represented principally by the overlying Herkimer Sandstone. The following species have been found in the Kirkland iron ore of the Richfield Springs quadrangle.

Schuchertella ? *subplana* (Conrad)

Bonnemaia cf. *transita* Ulrich and Bassler

Zygoseella cf. *vallata* Ulrich and Bassler

trilobite spp.

ostracode spp.

Herkimer Sandstone

The Herkimer Sandstone (Chadwick, 1918) was named from exposures of the Upper Clinton sandstone in southern Herkimer County. Although no specific exposure was cited as the type section, it is possible that Chadwick was referring to one or more of the many exposures of this sandstone found in the Richfield Springs quadrangle.

The Herkimer Sandstone, like the Sauquoit of the Middle Clinton, exhibits very impressive facies changes eastward from the Rome to the Richfield Springs quadrangles. In the former, the Herkimer consists of about equal proportions of gray, calcareous, thin-bedded sandstones and dark gray, sandy, and calcareous shales. A marine fauna characteristic of the Upper Clinton *Paraechmina spinosa* zone has been recorded from the area (Gillette, 1947, p. 112). To the east, a reduction in the number and thickness of the shale beds occurs. In the Utica quadrangle, some sandstones contain phosphatic nodules, clay gill layers, and quartz pebbles. When traced eastward into the Richfield Springs quadrangle, the shale beds largely disappear. The sandstones become much coarser grained, thicker, and weather white or light gray. Quartz pebbles become sufficiently abundant in some beds to permit them to be classified as conglomerates rather than sandstones. Cross-bedding becomes much more common. Fossils appear to be lacking, only occasional fucoids having been seen by the writer. The changes described above indicate that the eastern parts of the Herkimer are more shoreward portions of the formation.

The greater resistance of the Herkimer to weathering and erosion causes it to form terraces, waterfalls, and escarpments across the Richfield Springs quadrangle. The Herkimer is exposed in the high

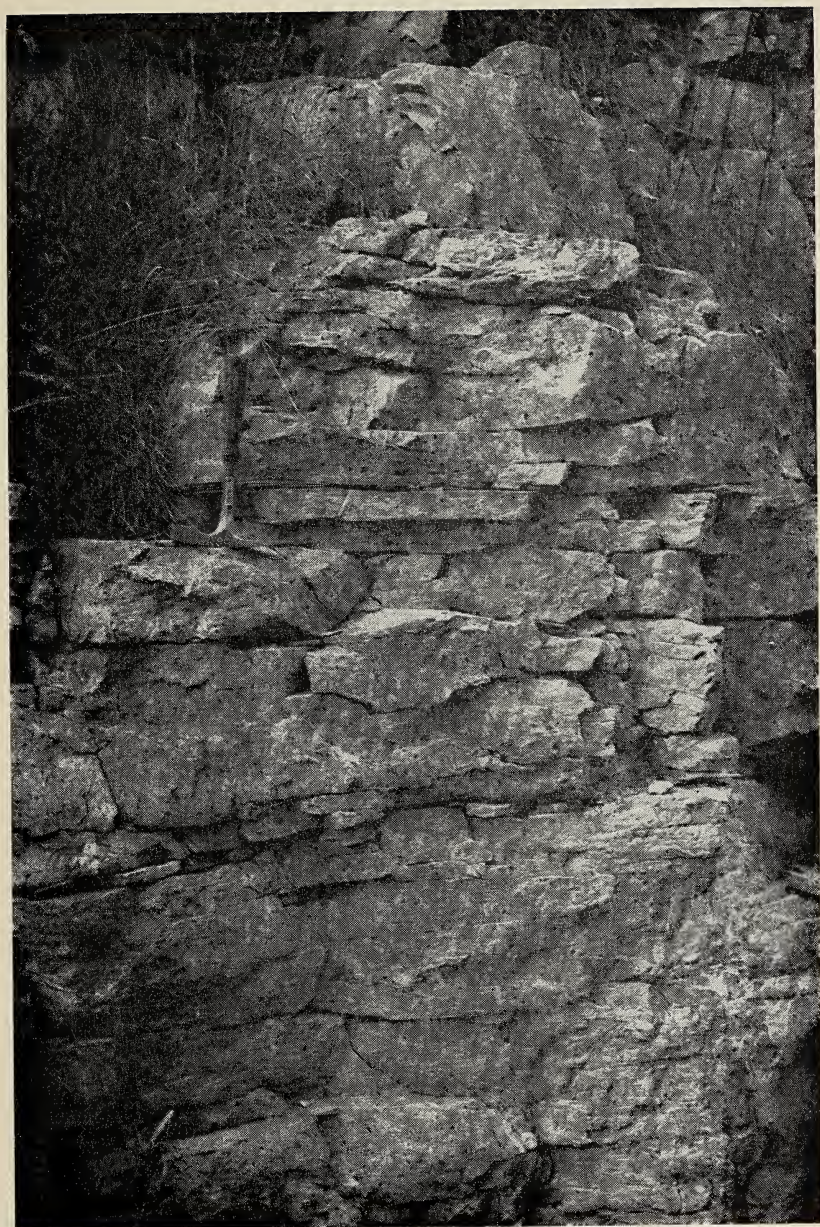


FIGURE 6. Herkimer Sandstone exposed in a road cut on Rock Hill, south of Edicks, Richfield Springs quadrangle. *Photograph by L. V. Rickard*

waterfalls of Flat Creek and the stream east of the abandoned railroad, south of Edicks. The former section displays some 40 feet of white, thin to medium-bedded sandstone; 20 feet are exposed in the latter where a 3-4 inch ore has been noted about 8 feet above the base (aneroid measurements in both sections). Both exhibit the basal contact with the underlying rocks, but lack exposure of the upper boundary. At Flat Creek, the Herkimer is overlain by the Vernon Shale; farther east, this unit is missing, and it underlies the Brayman. The contact must be unconformable in both sections since the intervening Lockport Group is absent.

A road cut south of Edicks contains an exposure of 38 feet, lacking top and bottom contacts. Thirty feet of Herkimer are exposed in the road cut south of Paines Hollow. Both east and west of these road cuts, high ledges of Herkimer Sandstone are exposed for some distances.

In the stream south of Deck, both the upper and lower contacts of the Herkimer can be seen. Fifteen feet of sandstone form the cap rock of a waterfall in the stream above the Willowvale. The unconformable upper contact of the Herkimer with the Upper Silurian Brayman shale was exposed by a small amount of digging into the bank along the road opposite the waterfall. The upper surface of the Herkimer was found to be quite irregular. The topmost portion of the sandstone beneath the unconformity is badly weathered, having decayed into loose sand grains, and is discolored by iron stains. This may be interpreted as an example of Paleozoic weathering which occurred here during the deposition of the Lockport and Vernon farther west.

No Herkimer Sandstone is present in the section along Ohisa Creek. As previously mentioned, the Kirkland Hematite is here unconformably overlain by the Brayman Shale. The Herkimer reappears briefly once more in the Clinton sections across the quadrangle in the exposure at the sharp bend in Route 80 at Van Hornesville. Here, 12 feet of sandstones overlying the Kirkland Hematite and unconformably overlain by the Brayman Shale have been referred to the Herkimer.

CAYUGAN SERIES

THE CAYUGAN SERIES, which comprises the Upper Silurian of New York, is well represented in the Richfield Springs quadrangle. Rocks

of Late Silurian age are exposed along the escarpment which crosses the northern half of the quadrangle. Since the Cayugan rocks are much less resistant than those of the underlying and overlying units, exposures are usually limited to stream beds. However, the number of streams descending the face of the escarpment which expose the Upper Silurian is sufficient to display significant changes in the rocks of the series.

In central New York, the type area, the Cayugan Series formerly included six stratigraphic units, in ascending order, the Vernon, Camillus, Bertie, Cobleskill, Rondout, and Manlius. Recent studies (Rickard, 1962) have demonstrated that the Manlius limestone at the top of the type Cayugan Series is contemporaneous with the Lower Devonian of eastern New York. Consequently, this formation can no longer be considered a part of the Upper Silurian. Evidence suggesting that the underlying unit, the Rondout, also may be Devonian in age has been discovered. The position of the upper limit of the Cayugan Series, the Silurian-Devonian contact, thus remains, at present, in doubt. For convenience, however, in this report the upper limit of the Cayugan Series will be assumed to be the top of the Cobleskill Limestone.

Vernon Shale

In central and west-central New York, a thick mass of red and green shale occurs at the base of the Cayugan Series. This unit, known as the Vernon Shale (Clarke, 1903), is approximately 400 feet thick in its type section near Vernon, Oneida County. It consists of dark red, crumbly shale with some grayish-green zones, particularly at the base, and beds of red shales with green spots. Bedding planes are very obscure, and the Vernon rapidly disintegrates upon exposure into small fragments. Consequently, it is exposed only where erosive agents are most active. In the type area and eastward to the Utica quadrangle, the Vernon overlies the Lockport Dolomite or Ilion Shale, apparently disconformably. The upper contact is gradational.

The Vernon may be traced eastward through the Rome, Utica, and Winfield quadrangles into the Richfield Springs area. Across these quadrangles, the Vernon gradually diminishes in thickness. Although it is about 200 feet thick in the adjoining Utica and Winfield quadrangles to the west, only 60 to 80 feet are present along the western boundary of the Richfield Springs quadrangle. Less than 20 feet of Vernon was found in the Flat Creek section, and no evidence for its existence was seen farther east. Apparently the Vernon Shale dis-

appears within 2 miles of the western border of the Richfield Springs quadrangle. Due to the absence of the Lockport Group, the Vernon unconformably overlies the Herkimer Sandstone of the Upper Clinton. It is gradationally overlain by the Brayman Shale above.

Exposures of the Vernon Shale occur along a small brook south of the paved road 0.4 mile east of Brown School, in the west branch of Flat Creek, 0.6 mile farther east, and above and below the road in the Flat Creek section. Contacts of the Vernon with other rock units are not displayed in these exposures, except that of the upper boundary in the Flat Creek section. No fossils have been recovered from the Vernon Shale in the Richfield Springs quadrangle.

Brayman Shale

The calcareous shales, dolomites, and limestones overlying the Vernon in central and western New York have long been known as the Camillus Formation (Clarke, 1903). Somewhat more resistant dolomites and shales of similar lithology, bearing eurypterids and overlying the Camillus, have been referred to the Bertie Formation (Chapman, 1864). In the subsurface, evaporite beds at the base of the Camillus were named the Syracuse salt by Clarke (1903). Recent work has defined these units more precisely, and the Syracuse Formation has been recognized in surface outcrops (Leutze, 1956, 1959; Fisher, 1960). When traced eastward into east-central New York, these three units lose their identifying characteristics. The Upper Silurian sections of the Richfield Springs quadrangle are not readily divisible into portions of Syracuse, Camillus, or Bertie age. Here, the entire interval between the Vernon and Cobleskill formations is referred to the Brayman Shale (Grabau, 1906; Fisher and Rickard, 1953).

The Brayman Shale consists principally of drab weathering, dark gray, thin-bedded shales and limestones which have variable argillaceous and dolomitic contents. Crumbly green shales are also abundant, particularly near the top of the formation and throughout it in the eastern portion of the quadrangle. All the rock is extremely fine-grained and weathers rapidly where exposed at the surface. Mud cracks and other evidence of deposition in shallow water have been observed. The presence of gypsum and anhydrite, salt-hopper crystals, and the lack of a normal marine fauna attest to the deposition of this unit in waters of abnormally high salinity. Specimens of the pelecypod *Ctenodonta salinensis* Ruedemann were obtained from the Brayman, exposed along a small stream 0.4 mile west-northwest of Salt Spring-

ville. Poorly preserved ostracodes and eurypterid fragments were seen in a somewhat more resistant waterline in the lower portion of the Brayman,¹ exposed along the road just north of Van Hornesville.

The Brayman Shale is seen overlying many different rock units as it is traced across the quadrangle. Its thickness gradually increases to the west. In the stream 0.8 mile southwest of Salt Springville, it rests unconformably upon the Ordovician Frankfort Shale and is about 100 feet thick. North of the Dugway Gorge and along the north side of Willse Hill, 120–160 feet of Brayman unconformably overlie the red, cross-bedded Otsquago facies of the Sauquoit Formation (Clinton Group). In the vicinity of Van Hornesville, the Brayman is approximately 200 feet thick and may be seen overlying different portions of the Clinton Group (Herkimer, Willowvale, or Sauquoit), depending upon the exact locality visited. It is characterized by large masses of calcareous tufa at and below the basal unconformity. These masses of tufa commonly occur at the base of the Brayman in the Richfield Springs quadrangle and characterize the base of the Camillus or Syracuse to the west. Apparently they owe their origin to the precipitation of calcareous materials from ground water which passes through the Brayman, dissolving calcareous and dolomitic portions of the rock.

Northwestward, from Van Hornesville to Flat Creek, the Brayman Shale maintains a thickness of approximately 200 feet. It unconformably overlies various parts of the Clinton Group from place to place. (See discussion of the Clinton formations.) At Flat Creek, the Vernon red shale appears beneath the Brayman with gradational contact and continues to the western border of the quadrangle. In the area west of Flat Creek, it has been noted that the Vernon Shale increases in thickness at the expense of the Brayman; i.e., the entire Vernon-Syracuse-Camillus-Bertie interval at the western border of the quadrangle does not appear to be much greater than that assigned to the Brayman to the east. In contrast to the many units which unconformably underlie the Brayman Shale at various localities, only one formation continuously overlies it. The Cobleskill limestone and dolomite overlies the Brayman with a slight disconformity everywhere across the quadrangle.

Continuous exposures of the Brayman Shale are few, due to the weak nature of the rocks of which it is composed. Fairly continuous

¹ This exposure formerly (Fisher and Rickard, 1953, p. 9) was referred to the lower or Fiddlers Green Member of the Bertie Formation. Its stratigraphic position near the base of over 200 feet of Brayman, however, indicates that this horizon is well below any Bertie equivalent in this vicinity.

exposures are to be found along the streams 0.4 to 0.8 mile west of Salt Springville. The upper 36 feet of the formation is well exposed beneath the Cobleskill in a road cut at the west end of the Dugway Gorge, southwest of Salt Springville. Several streams descending the east and north sides of Willse Hill contain intermittent exposures of the Brayman. In the vicinity of Van Hornesville, a stream 0.5 mile north of the school in the village displays a fairly continuous section. The Brayman may be seen unconformably overlying the Herkimer Sandstone of the Clinton Group at the sharp bend in Route 80, west of the village. The southern portion of the gorge, along Ohisa Creek, contains a fine section of the lower portion of the Brayman. Here it may be seen unconformably overlying the Kirkland Hematite or the Willowvale Shale beneath. The unconformity cuts the former out of the section to the north (downstream). Numerous hillside and stream exposures of the Brayman exist along the hillside south of Smith Corners westward to Deck. Large masses of calcareous tufa commonly are encountered along the basal unconformity. In the gorge south of Deck, the unconformable lower contact with the Herkimer Sandstone exposed here has already been described. In the western portion of the quadrangle, only the exposure at Flat Creek — exhibiting a gradational contact with the underlying Vernon — deserves mention.

Cobleskill Limestone

Across the Richfield Springs quadrangle, the Cobleskill Limestone (Clarke, 1902; Hartnagel, 1903) is seldom exposed and, where studied, does not seem to contain the fairly large fauna so evident at the type section in the Schoharie quadrangle to the east. The formation here has a thickness of about 10 or 12 feet, similar to that of the type area, but consists of more argillaceous and dolomitic limestones which weather to a drab yellowish-gray rather than the dark blue or gray, purer limestones found in the type region. The limestone is mottled with blue and gray spots, thin- to medium-bedded and, in some portions of the rock, displays numerous pits and vugs containing calcite crystals.

The Cobleskill overlies the Brayman Shale with a thin layer of limonite along the basal contact, possibly indicative of a slight unconformity. It is gradationally overlain everywhere by the Chrysler Dolomite. The upper contact with the Chrysler is difficult to place. In this quadrangle, only disappearance of the Cobleskill fauna and

introduction of the straticulate bedding of the Chrysler serve to identify it.

The only good exposure of the Cobleskill and Chrysler formations in the Richfield Springs quadrangle is that in the road cut at the west end of the Dugway Gorge, 1 mile southwest of Salt Springville on the road to East Springfield. Here 11 feet of Cobleskill are exposed beneath 32 feet of Chrysler above and more than 30 feet of Brayman Shale below. The Cobleskill is only slightly fossiliferous here. Its fauna includes the species listed below.

"Camarotoechia" litchfieldensis (Schuchert)

Fardenia interstriata (Hall)

Leptostrophia bipartita (Hall)

Halysites catenularia (Linnaeus)

Favosites sp.

Stromatopora sp.

Small unidentified tetracoral

The small tetracoral and *Halysites catenularia* are most common in the upper 5 feet of the Cobleskill. *Favosites* and *Stromatopora* range throughout the formation. Corals in the basal 2 feet have been overturned, indicative of wave or current activity during the deposition of the limestone.

Elsewhere in the quadrangle, the Cobleskill may be seen in the small stream 0.8 mile west of Salt Springville and at several points along the paved road 0.5 mile south of Deck. These exposures are very incomplete, serving only to indicate the continuity of the Cobleskill across the quadrangle.

DEVONIAN SYSTEM

HELDERBERGIAN SERIES

THE LARGEST PORTION of the Richfield Springs quadrangle and all the Cooperstown quadrangle are underlain by rocks of Early, Medial, and Late Devonian age. About 3,000 feet of limestones, shales, and sandstones are exposed throughout the southern two-thirds of the combined quadrangles. Over 2,000 feet of this consists of limestones, shales, and sandstones of Medial Devonian age, referred to the Erian Series. An additional 700 feet of shales and sandstones overlie this

thick sequence of clastics and comprise the lower portion of the Senecan Series of Late Devonian age. The Early Devonian strata consist largely of limestones, approximately 250 feet thick, which represent portions of two Lower Devonian series — the Helderbergian and overlying Ulsterian.

The lower Devonian Helderbergian Series is exposed in the upper portion of the escarpment which crosses the Richfield Springs quadrangle from east to west. Several stream valleys cut into the escarpment cause deep southerly indentations in the outcrop belt. These are located along the Salt Springville-East Springfield valley and along the valley of Hayden Creek next to the west. Helderbergian strata are exposed in numerous hillside outcrops, stream beds, quarries, and road cuts throughout their outcrop belt. Facies changes of considerable importance are displayed from east to west. In the Richfield Springs quadrangle, the Helderbergian consists largely of limestones of various types and averages about 210 feet in thickness. Subdivisions are indicated below.

Formation		Approximate Thickness
Kalkberg Limestone		15-50 ft.
Deansboro Limestone	30-40 ft.	} Ravena Limestone 90-100 ft.
Jamesville Limestone	0-15 ft.	
Clark Reservation Limestone	0-3 ft.	
Elmwood Limestone	0-20 ft.	
Dayville Limestone	40-50 ft.	
Thacher Limestone		30-40 ft.
Chrysler Dolomite		30-40 ft.

A detailed discussion of the important facies changes which occur within the Helderbergian Series across New York State is given in another report (Rickard, 1962). However, it may be of interest to mention the fact that it is within the Richfield Springs region that most of the significant changes in the stratigraphic relationships of the Lower Devonian units take place.

Chrysler Dolomite

The senior author (Rickard, 1962) has recently suggested that the name *Chrysler* (Chadwick, 1930) be adopted for the shaly dolomites and calcareous shales between the Cobleskill and Manlius of central New York. These strata have long been referred to the Rondout Formation but differ in lithology, fossil content, stratigraphic position,

and age from the type Rondout of the Hudson River Valley. In the Richfield Springs quadrangle, the Chrysler apparently maintains a consistent thickness of about 35 feet. Where exposed, the dolomite is light gray or bluish gray on fresh surfaces but weathers yellowish-brown. It possesses a conchoidal fracture in contrast to the irregular fracture of the more calcareous Cobleskill beneath. The bedding is often straticulate; i.e., composed of innumerable extremely thin laminae, each not over several millimeters in thickness. Because of the soft nature of the rock, it weathers rapidly and is much less commonly exposed than any other formation occurring in the quadrangle. Consequently, many of the details of the formation are unknown.

The only exposure of the Chrysler in this area which is nearly complete is that in the road cut west of Salt Springville, described above. Elsewhere, it is almost always concealed beneath covering materials. No fossils have yet been recovered from the Chrysler Dolomite in this quadrangle. It is everywhere overlain by the Thacher Limestone, apparently with a gradational contact.

Thacher Limestone

The name *Thacher Limestone* has been proposed (Rickard, 1962) for the dark bluish-black, fine-grained limestones above the Chrysler and below the Coeymans in the escarpment present in John Boyd Thacher Park, southwest of Albany. This limestone has long been considered a part of the Manlius Formation (Vanuxem, 1840) of central New York. It was known in earlier days as the "Tentaculite" limestone, so named by Gebhard, Mather, Hall, and others because of the great abundance of the small conical shell *Tentaculites gyraacanthus*. However, recent studies have shown that this unit is stratigraphically lower and older than any previously recognized portion of the type Manlius. Hence the necessity for a new geographic name to designate this rock unit.

In the Richfield Springs quadrangle, the Thacher Limestone maintains a nearly constant thickness of about 35 feet. It may be subdivided in the eastern portion of the quadrangle and eastward to the type section into two parts, based upon slightly different lithologies. These divisions are indistinguishable east of the Deck meridian into central New York. The lower division consists of about 25 feet of dark, fine-grained limestones in beds 1 to 2 inches in thickness. This is the typical "ribbon" or "Tentaculite" limestone of the earlier workers. It is about 95 per cent soluble in dilute hydrochloric acid, the residue being a black organic (?) material. Although dark on fresh surface,

the strata weather light colored or whitish. Bedding planes are smooth and even. Loose pieces of this lithology often ring or clink when struck. Cross-bedding, mudcracks, and faint ripplemarks have been noted. In general, the fauna is few in numbers of species but profuse in numbers of individuals. The lower contact with the Chrysler below is gradational. At the top of this division east of the Deck meridian, a variable thickness of drab, yellowish weathering, thin-bedded waterlimes indicates the boundary with the overlying division. These waterlime beds, 0 to 5 feet thick, apparently are replaced westwardly by typical Thacher Limestone in surface outcrops but have been recognized in drill cores even in the Winfield quadrangle.

The upper division consists of about 10 to 15 feet of dark blue fine-grained limestones, more thickly bedded and more fossiliferous than those of the underlying strata. Stromatoporoid biostromes varying from 0 to 3 or 4 feet in thickness occur sporadically at the top across the quadrangle. The contact with the overlying rocks is gradational where the biostromes are absent or sharp but not disconformable where they are present. The upper division of the Thacher contains the lower of two stromatoporoid biostromes encountered in the Richfield Springs quadrangle. This is the only area across New York State where the biostromes of the upper Thacher may be readily distinguished from those of the higher Jamesville Limestone. The Thacher is overlain by the Ravena Limestone in the east and by the Dayville Limestone in the central and western parts of the quadrangle.

Exposures of the Thacher Limestone are numerous, but most of them do not display complete sections. Normally, only the upper portion of the formation is observable; the lower contact with the Chrysler below is usually concealed. Hillside outcrops, quarries, and road cuts afford the most favorable exposures of the Thacher. One of the best exposures of the Thacher known to the writer occurs at the base of Judds (Tarakarawa) Falls, 1.8 miles north-northeast of Cherry Valley, just east of the eastern border of the quadrangle. Here, 44 feet of Thacher is completely exposed and may be subdivided into the two divisions described above by a 5-6 foot interval of waterlimes. No stromatoporoid biostrome is present at the contact with the overlying Ravena Limestone about 11-12 feet above the top of the waterlime.

In the Richfield Springs quadrangle, the uppermost Thacher is exposed in the cliffs and quarry west of the road from East Springfield to Willse Four Corners in the area 0.5 to 1 mile southwest of the latter intersection. A 2-foot stromatoporoid biostrome midway up the quarry wall and in the cliffs marks the contact with the overlying Dayville Limestone. This biostrome is also well exposed along the

north side of Willse Hill, south of the Willse Four Corners-Van Hornesville paved road. Nearly the entire Thacher is well displayed in an abandoned quarry just south of the same road at a point 0.4 mile north of Willse Four Corners. Twenty-five feet of limestones lacking abundant *Tentaculites gyracanthus* in the upper part and overlain by 2 feet of waterline beds make up the lower division. Fifteen feet of limestones capped by a stromatoporoid biostrome in the field above the quarry form the overlying division. The floor of the quarry apparently is very close to the top of the Chrysler. The Dayville Limestone is exposed in ledges along the hillside above the biostrome.

The biostrome of the upper division is well exposed in the quarry and hillside southwest of the State Fish Hatchery at Van Hornesville and in the quarry on the northwest side of the limestone outlier, 1.1 miles north of Van Hornesville. In both of these localities, the upper division, capped by a stromatoporoid biostrome 3 feet thick, totals approximately 15 feet. The waterline zone at the top of the lower division beneath is also displayed and is underlain by the typical laminated blue limestone of the lower Thacher. The Thacher biostrome may be seen in the hillside south of the paved road at a point 2.7 miles east of Crains Corners. It should not be confused with the much thicker and more prominent Jamesville biostrome also exposed here at the top of the steep slope near the road and approximately 60-70 feet higher.

A limestone outlier 1 mile southwest of Smith Corners contains numerous exposures of the upper Thacher biostrome. Along the hillside paralleling the paved road next southwest of this outlier, both the Thacher and Jamesville biostromes may be observed in several outcrops. The Thacher biostrome is well exposed in a small quarry 1.1 miles south of Deck. It is about 2 feet thick and is underlain by 12 feet of limestones containing a second biostrome 3 feet from the top.

In the western portion of the quadrangle, the upper Thacher is exposed in a small quarry west of the dirt road 1.4 miles north of Jordanville. There is no biostrome here at the top of the Thacher and the contact with the overlying Dayville Limestone is difficult to establish. The Thacher is not exposed in the large active quarry to the south near Jordanville. Near the western border of the quadrangle only the outcrops along the east side of the hill 1 mile northwest of Kingdom and 0.4 mile west of the Henderson Cemetery deserve mention. Here 40 feet of laminated blue limestones capped by a biostrome 2 feet thick are intermittently exposed.

The fauna obtained from the Thacher Limestone of this quadrangle is listed below. It is poor in numbers of species, but several of these,

as indicated, occur in great abundance.

Syringostroma barretti Girty, very common
Brachyprion varistriata (Conrad), common
Howellella vanuxemi (Hall), very common
Monotrypella ? *arbuscula* (Hall)
Megambonia aviculoidea (Hall)
Tentaculites gyracanthus (Eaton), common
Leperditia alta (Conrad), very common
Holopea antiqua (Vanuxem)

Numerous ostracodes belonging in the genera *Kloedenella*, *Kloedenia*, and others are also commonly encountered. As most of these belong to genera and species not yet formally recognized, they have not been included in the list above.

Ravena Limestone

Entering this area from the Canajoharie quadrangle, next eastward is a thick mass of coarse-grained, irregularly bedded and fossiliferous limestone long known as the Coeymans (Clarke and Schuchert, 1899). The Coeymans abounds in specimens of the pentamerid brachiopod *Gypidula coeymanensis* and for this reason was known to earlier geologists as the "Lower Pentamerus" limestone. It is 100 feet thick at Judds Falls, north-northeast of Cherry Valley, and apparently maintains this thickness throughout the eastern quarter of the Richfield Springs quadrangle.

When traced westward, however, significant changes in the central portion of this thick limestone unit take place. In the exposures along the east, north, and west sides of the ridge between Willse Four Corners and Summit Lake, a unit of different lithology appears in the middle of the Coeymans. This central unit consists of dark blue, even and thinly bedded, fine-grained limestones, relatively unfossiliferous and capped by a very thin stromatoporoid biostrome. This interval of different lithology increases in thickness westwardly across the quadrangle at the expense of the typical Coeymans. *Gypidula coeymanensis* is found both above and below it. The stromatoporoid biostrome thickens and becomes quite prominent in the sections in the western half of the quadrangle. Here, this interval is divisible into units of Manlius lithology which contain a Manlius fauna.

When traced westward into central New York, these Manlius units are seen to be continuous with, and indeed are, the Elmwood, Clark Reservation, and Jamesville Members of the type Manlius Formation.

The portion of the Coeymans which underlies them gradually changes laterally into a Manlius lithology. Its fauna simultaneously changes from that of Coeymans to one of Manlius aspect. In central New York, it is known as the Olney Member of the type Manlius Formation. The upper portion of the Coeymans above these Manlius members continues unchanged into central New York, where it is represented by the Bishop Brook Limestone overlying the type Manlius.

Three new stratigraphic names are necessary to identify readily various portions of the Coeymans Limestone in the Richfield Springs quadrangle. The name *Ravena* (Rickard, 1962) has been suggested for the undivided Coeymans of eastern New York. An abandoned quarry near Ravena in the Coxsackie quadrangle serves as the type section. For that portion of the Coeymans which grades westwardly into the Olney Member of the Manlius, Rickard has proposed the name Dayville, from the fine exposures of this interval in the hillside west of Dayville in the Winfield quadrangle. The name Deansboro has been applied to the upper portion of the Coeymans which extends westward into central New York. Its type section is in the west wall of the large active quarry at Oriskany Falls in the Sangerfield quadrangle. Consequently, the name Ravena will be used herein for that portion of the coarse-grained, irregularly bedded and fossiliferous limestones found in the eastern quarter of the Richfield Springs quadrangle. Elsewhere in this quadrangle where rocks of this lithology are separated by beds of Manlius type, the names Dayville and Deansboro will be applied.

The observations outlined above indicate that a lateral facies change between two different types of limestones, the products of deposition in considerably different environments, occurs across the Richfield Springs quadrangle. The Manlius Formation, composed of five members, in ascending order, the Thatcher, Olney, Elmwood, Clark Reservation, and Jamesville, has been interpreted as a near-shore, quiet water, lagoonal deposit. It interfingers with the more off-shore phase represented by the typical Coeymans — the Ravena, Dayville, and Deansboro Limestones.

The Ravena consists of very hard, coarse-grained, gray or blue crystalline limestones. It weathers dark gray or brownish and has a rough appearance. Bedding is usually massive, individual layers varying from 10 inches to several feet in thickness. When weathered, these massive beds often display a stratification whose bedding planes are quite irregular or "wavy." Scattered throughout the formation are frequent lenses or beds entirely composed of the valves of the brachiopod *Gypidula coeymanensis* and the columnals of crinoids or cystoids. These are often in such abundance that the rock may be

termed a coquinite. The greater resistance of the Ravena to weathering and erosion makes it the cap rock of prominent escarpments. The Ravena overlies the Thatcher Limestone with sharp or gradational contact and underlies the Kalkberg Limestone. Its upper boundary is gradational; passage from the Ravena into the Kalkberg is indicated by the introduction of chert beds and some, but not drastic, changes in lithology and fauna.

As used in the Richfield Springs quadrangle, the name *Ravena* designates the 90 to 100 feet of coarse-grained limestones found in the area east of the road from Willse Four Corners to East Springfield. In this portion of the quadrangle, the Coeymans is not readily divisible into two parts separated by an interval of Manlius lithology. Exposures are frequent in the hill southeast of Willse Four Corners and along the hillside south of the road between Salt Springville and East Springfield. The Ravena is almost completely exposed at Judds Falls, just east of the quadrangle, and in the stream bed and hillside 1.5 miles and 0.7 mile south of Salt Springville at the eastern border of the quadrangle. Its thickness varies from 90 to 105 feet in these sections. The hillside south of the Dugway Gorge, at a point 1.2 miles southwest of Salt Springville, contains intermittent exposures totaling about 100 feet in thickness.

The Ravena Limestone has yielded the following species from various exposures east of the road between Willse Four Corners and East Springfield.

BRACHIOPODS

- Anastrophia verneuili* (Hall)
- Atrypa reticularis* (Linnaeus), very common
- Brachyprion varistriata* (Conrad), common
- Camarotoechia semiplicata* (Conrad)
- Gypidula coeymanensis* Schuchert, very common
- Leptaena rhomboidalis* (Wilckens)
- Leptostrophia planulata* (Hall)
- Meristella laevis* (Vanuxem), common
- M. praenuntia* Schuchert
- Rhipidomelloides oblata* (Hall)
- Howellella cyclopterus* Hall
- Strophonella punctulifera* (Conrad), common
- Uncinulus mutabilis* (Hall), very common

MISCELLANEOUS

- Lepocrinites gebhardii* Conrad
- Dalmanites litchfieldensis* Delo
- Odontochile micrurus* (Green)

Favosites helderbergiae Hall, very common

Enterolasma strictum (Hall)

Tremanotus profundus (Conrad)

Dayville Limestone

Whereas the lithology of the Dayville Limestone is predominantly like that of the Ravena to the east, it contains beds indicative of the lateral gradation of this unit into the Olney Limestone. Coarse-grained, gray, crinoidal limestones like those of the Ravena gradually are replaced westwardly by fine-grained, dark blue limestones typical of the Olney. Beds of Olney-like limestone increase in number and thickness westward. The bedding, like that of the Ravena, is massive and irregular. The fauna of the Dayville is somewhat reduced, though typically Coeymans and not Manlius in aspect.

The Dayville gradationally overlies the Thacher Limestone across the quadrangle. Its upper boundary, also gradational, is less often exposed than the lower contact. Its thickness gradually decreases from 50 feet in the east to about 40 feet along the western border of the quadrangle, part of the loss due to replacement of the upper beds by the overlying, thickening interval of Manlius lithology and fauna. The Dayville is exposed in many localities throughout its outcrop belt. These exposures usually exhibit only the lower portion of the formation.

Numerous hillside outcrops of the Dayville Limestone are located along the north and east sides of the hill west of Willse Four Corners. It is approximately 40 feet thick in this area. The Manlius interval above is about 20 feet in thickness and is usually concealed. Exposures of the Dayville in this area have yielded the fauna listed below.

BRACHIOPODS

Atrypa reticularis (Linnaeus), very common

Brachyprion varistriata (Conrad), very common

Gypidula coeymanensis Schuchert, common

Leptostrophia planulata (Hall), common

Meristella laevis (Vanuxem)

M. sp.

Rhipidomelloides oblata (Hall), common

Schuchertella woolworthana (Hall)

Strophonella punctulifera (Conrad), common

Uncinulus mutabilis (Hall), very common

MISCELLANEOUS

Michelinoceras rigidum (Hall)

Dalmanites sp.

Favosites helderbergiae Hall, very common

Exposures of the lower portion of the Dayville Limestone are commonly encountered along the hillside southwest of Van Hornesville and form the cap rock of the limestone outlier 1.1 miles north of Van Hornesville. From the latter locality, the following species have been collected from the lower 15 to 20 feet of Dayville Limestone present there.

Atrypa reticularis (Linnaeus)

Brachyprion varistriata (Conrad), very common

Camarotoechia semiplicata (Conrad), very common

Strophonella punctulifera

Uncinulus mutabilis (Hall)

U. sp.

Actinopteria sp.

In the hillside south of the paved road 2.7 miles east of Crains Corners, the Dayville is exposed in hillside ledges above the Thacher Limestone. It measures about 40 feet in thickness and is overlain by about 30 feet of Manlius strata, largely concealed, the upper 10 feet of which consist of a very prominent stromatoporoid biostrome (Jamesville). The Dayville Limestone in this area has yielded the following fauna.

Atrypa reticularis (Linnaeus)

Brachyprion varistriata (Conrad), very common

Leptostrophia planulata (Hall)

Meristella sp.

Rhipidomelloides oblata (Hall)

Schuchertella woolworthana (Hall)

Strophonella punctulifera (Conrad)

Uncinulus mutabilis (Hall)

Favosites helderbergiae (Hall), common

Stromatopora sp.

The Dayville Limestone forms the cap rock of the limestone outlier 1 mile southwest of Smith Corners and is well exposed in ledges along the hillside next southwest. In the latter area and along the hillside south of Deck, it is about 40 feet thick. About 20 feet above its top is a prominent stromatoporoid biostrome (Jamesville) which forms the cap rock of the steep slope southwest of the road. The following species were collected here.

Brachyprion varistriata (Conrad)
Camarotoechia semiplicata (Conrad)
Leptostrophia planulata (Hall)
Rhipidomelloides oblata (Hall)
Strophonella punctulifera (Conrad)
Uncinulus mutabilis (Hall)
Favosites helderbergiae (Hall)
Dalmanites litchfieldensis Delo

In the western portion of the quadrangle, 18 feet of Dayville are exposed along the base of the wall in the large active quarry 0.5 mile north of Jordanville. *Atrypa reticularis*, *Brachyprion varistriata*, *Leptostrophia planulata* and *Schuchertella woolworthana* were collected here. Near the western border, only the hillside 1 mile northwest of Kingdom and 0.4 mile west of the Henderson Cemetery exhibits good exposures of the Dayville Limestone. Its fauna does not contain any elements not seen in other Dayville exposures.

A list of all the species known to occur in the Dayville Limestone of the Richfield Springs quadrangle is given below. This list includes species reported by earlier workers in addition to those cited above. It does not include several species, principally ostracods and brachiopods, known to occur in the Dayville, whose names are not yet formally recognized. A very small proportion of typically *Manlius* forms occurs. This is not unexpected because the Dayville lithology, while for the most part like that of the Coeymans, contains strata of finer grain and more even bedding, resembling the typical *Manlius*. In general, the fauna of the Dayville Limestone is one of Coeymans aspect. This and its lithology indicate that the Dayville must be associated with the Coeymans rather than the Olney or *Manlius*.

BRACHIOPODS

Atrypa reticularis (Linnaeus), very common
Brachyprion varistriata (Conrad), very common
Camarotoechia altiplicata (Hall)
C. semiplicata (Conrad), common at base
Cyrtina sp.
Gypidula coeymanensis Schuchert, common in east only
Howellella sp.
Leptostrophia planulata (Hall), common
Meristella laevis (Vanuxem)
M. praenuntia Schuchert
M. princeps (Hall)
Rhipidomelloides oblata (Hall), common
Schizophoria cf. *multistriata* (Hall)



FIGURE 7. North wall of the General Crushed Stone Company quarry at Jordanville, Richfield Springs quadrangle, exposing the Dayville, Elmwood, Clark Reservation, Jamesville, and Deansboro Limestones. *Photograph by L. V. Rickard*

Schuchertella woolworthana (Hall)
Strophonella punctulifera (Conrad), common
Ucinulus mutabilis (Hall), very common
U. nucleolatus (Hall)

OSTRACODES

Dizygopleura sp.
Kloedenella planata (Ulrich and Bassler)
Kloedenia granulata (Hall)
K. manliensis (Weller)
Mesomphalus hartleyi Ulrich and Bassler

BRYOZOANS

Fistulipora torta (Hall)
Monotrypa sphaerica (Hall)
Monotrypella ? arbuscula (Hall)

PELECYPODS

Actinopteria textilis (Hall)
Avicula obliquata Hall
Megambonia aviculoidea Hall
M. spinneri Hall
Pterinea naviformis (Conrad)

TRILOBITES

Dalmanites litchfieldensis Delo
Odontochile micrurus (Green)

MISCELLANEOUS

Michelinoceras rigidum (Hall)
Lepocrinites gebhardii Conrad
Platyceras sp.
Favosites helderbergiae Hall, very common
Syringostroma barretti Girty
Tentaculites elongatus Hall
T. gyracanthus (Eaton)

Elmwood, Clark Reservation, and Jamesville Limestones

These three rock units, forming the upper three members of the type Manlius, will not be discussed individually because of the difficulty of separating them in the Richfield Springs quadrangle. In central New York, these are readily distinguished, but in this area only the Jamesville can be easily identified.

The Elmwood Member (Smith, 1929) of central New York, overlying the Olney Limestone, is divisible into three parts known as Elmwood A, B, and C in ascending order, totaling about 15 feet in thickness. Elmwood A and C are units of drab yellowish-brown thin-bedded waterlimes whereas the middle unit, B, is composed of fine-grained blue limestone. Eastward from central New York, the waterlime units A and C are replaced by limestones similar to unit B. In the Richfield Springs quadrangle, the entire Elmwood interval consists of fine-grained, thin and evenly bedded, dark blue limestones which weather to a drab brownish color.

The Clark Reservation Limestone (Smith, 1929), 3 to 4 feet thick, above the Elmwood in central New York, is composed of fine-grained, dark blue limestone which weathers a very light blue. It is characterized by a diagonal fracture system. When traced eastward into the Richfield Springs quadrangle, the fracture system disappears, and its lithology becomes similar to that described above for the eastern portion of the Elmwood.

Overlying the Clark Reservation Limestone in central New York, Smith (1929, pp. 25-35) distinguished two members in the type Manlius Formation. Recent work (Rickard, 1962) has indicated no necessity for the name Pools Brook applied by Smith to strata overlying the Jamesville. The entire interval of fine-grained, dark blue limestones in thin, even beds, containing stromatoporoid biostromes at several stratigraphic horizons, is referred to the Jamesville Member. The Jamesville, thus defined, overlies the Clark Reservation, underlies the Bishop Brook and Deansboro Limestones, and is 10 to 25 feet in thickness. When traced eastward across the State, stromatoporoid biostromes are seen to occur sporadically throughout the member. In some areas, as in the Richfield Springs quadrangle, nearly the entire unit is composed of such biostromes.

In this quadrangle, the Elmwood-Clark Reservation-Jamesville interval consists of dark blue or gray, fine-grained, thin and evenly bedded limestones containing a stromatoporoid biostrome, 0 to 15 feet in thickness, at the top. This interval decreases from about 30 feet at the western border to less than 20 feet in the hillside southwest of Willse Four Corners, finally disappearing near the eastern border of the quadrangle. The loss in thickness apparently occurs both from the base upward and downward from the top through an eastward replacement of the fine-grained, dark blue limestones and stromatoporoid biostromes by rocks of Coeymans lithology. The lower contact with the Dayville is gradational and difficult to establish. The upper boundary between the stromatoporoid biostrome and the overlying Deansboro is sharp but not disconformable. Both contacts are

favorably exposed only in the large quarry north of Jordanville. The section here reveals, in ascending order, 18 feet of Dayville, 18 feet of fine-grained blue limestone (Elmwood), 3 feet of drab-weathering limestone (Clark Reservation ?), 12 feet of limestones and stromatoporous biostromes (Jamesville), and 10 or more feet of Deansboro. This is the only locality in the Richfield Springs quadrangle where the entire interval is fully exposed for study and where it seems possible to divide it into the three Manlius units.

Elsewhere in this area, usually only the Jamesville biostrome and a variable thickness of underlying beds of Manlius lithology are exposed. A good example of such an exposure is that in a small quarry west of the dirt road, 0.4 mile south of Kingdom. A pit just within the woods on the hillside 1 mile northwest of Kingdom displays a similar section.

The Jamesville biostrome is quite prominent at the localities mentioned above, around the hill northwest of Jordanville, and in the hillside south of Deck, extending southward to the road between Crains Corners and Van Hornesville. It maintains a thickness of about 10 feet and forms the cap rock of many steep slopes due to its more resistant nature. The Jamesville biostrome may be distinguished from that at the top of the Thatcher Limestone, 60 to 70 feet lower, by its matrix of gray color and slightly coarser grain size, and the much larger and better preserved stromatopores it contains. The Jamesville is not present in the limestone outlier southwest of Smith Corners or the outlier north of Van Hornesville. It is poorly exposed in the second small patch of woods up the hillside west of the State Fish Hatchery at Van Hornesville and along the edge of the woods 1 mile northwest of Summit Lake.

Farther eastward, in the ridge between Summit Lake and Willse Four Corners, the Jamesville rapidly thins and is difficult to find. It was located about two-thirds of the way up a steep slope above the Dayville Limestone and 60 feet above the Thatcher biostrome in the hillside south of the paved road 1.2 miles northwest of Willse Four Corners and 0.7 mile northeast of the Willse triangulation station. The easternmost locality in this quadrangle where the Jamesville horizon has been discovered is that in the hillside 1.1 miles southwest of Willse Four Corners and 1.3 miles due south of the exposure just described. At this locality, a Jamesville biostrome does not appear to be present. An interval, about 19 feet thick and composed of poorly exposed, medium-grained blue limestones, weathering brown, forms a steep slope between the Dayville below and Deansboro above. At the top of this interval, 60 feet above the Thatcher biostrome exposed in a small quarry below, a layer containing pebbles and abundant

Favosites sp. occupies the position of the Jamesville. The coarse-grained, gray, crinoidal limestones of the Deansboro and Dayville above and below contain *Gypidula coeymanensis*.

The fauna of the Elmwood-Clark Reservation-Jamesville interval across the Richfield Springs quadrangle is a very small one but definitely of Manlius aspect. From various exposures of this interval in the quadrangle, the following species have been collected.

- Brachyprion varistriata* (Conrad)
- Howellella vanuxemi* (Hall)
- Leptostrophia planulata* (Hall)
- Leperditia alta* (Conrad)
- Holopea antiqua* (Vanuxem)
- Strophostylus fitchi* (Hall)
- Megambonia* cf. *aviculoidea* Hall
- Enterolasma* sp.
- Favosites helderbergiae* Hall
- Syringostroma barretti* Girty, very common

Deansboro Limestone

In the Richfield Springs quadrangle, the Deansboro consists of hard, resistant, coarse-grained and crinoidal, gray or blue limestones like those of the Ravena to the east. Similarly, its bedding is massive and irregular. It weathers to the same dark gray or brownish color and rough appearance. Its fauna is Coeymans in aspect. The lower boundary with the Jamesville biostrome is sharp but not disconformable. The upper contact is gradational and more difficult to establish.

The thickness of the Deansboro decreases westwardly across the quadrangle from a maximum of 40 feet in the east to about 30 feet along the western border. Exposures of the Deansboro are usually incomplete. The lower portion is exposed in ledges along the hillside at points 1.1 and 1.6 miles southwest of Willse Four Corners.

The fauna listed below was obtained from beds exposed by the construction of a gas pipeline at the latter locality.

- Anastrophia verneuili* (Hall)
- Atrypa reticularis* (Linnaeus)
- Brachyprion varistriata* (Conrad)
- Gypidula coeymanensis* Schuchert
- Leptaena rhomboidalis* (Wilckens)
- Meristella* sp.
- Howellella cyclopterus* Hall

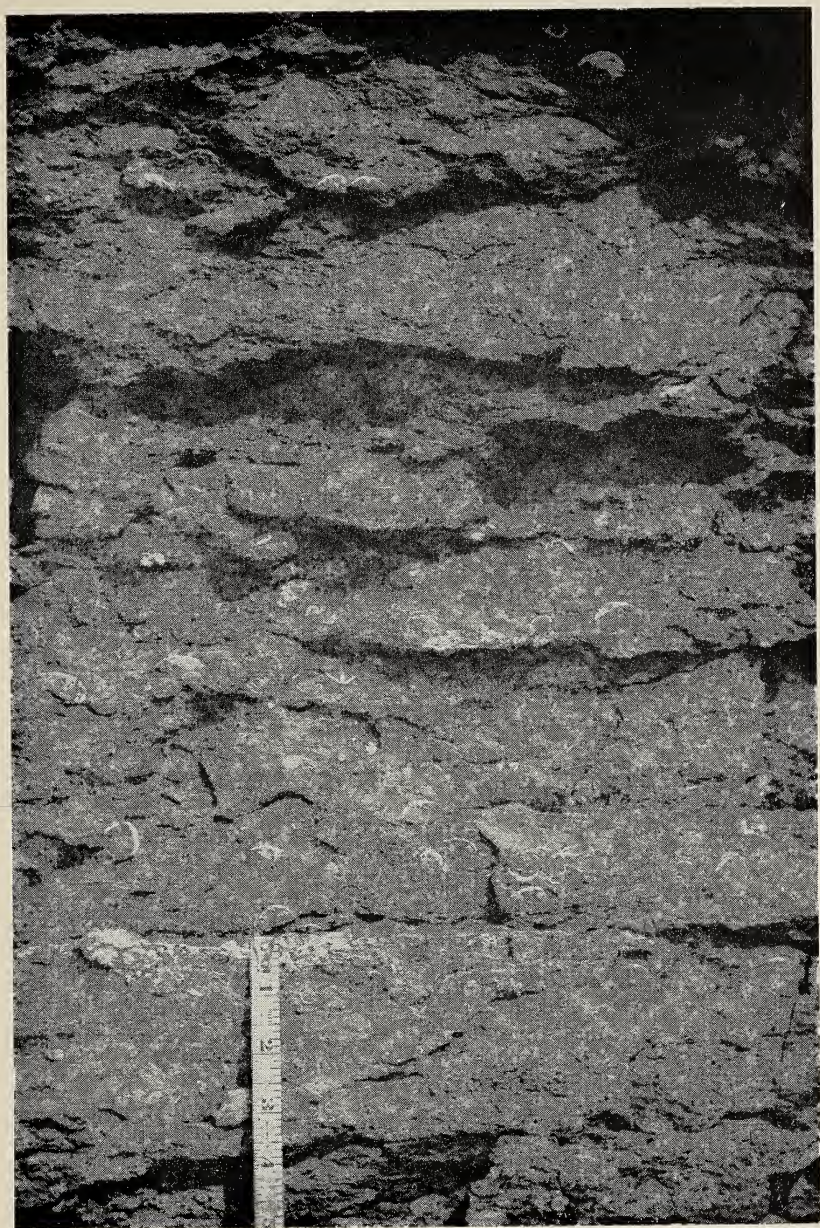


FIGURE 8. Irregular bedding planes and brachiopod shells (*Gypidula coeymanensis*) in the Deansboro Limestone, abandoned quarry 0.3 mile northwest of Cullen, Richfield Springs quadrangle.

Photograph by L. V. Rickard

Strophonella punctulifera (Conrad)

Uncinulus sp.

Favosites sp.

Enterolasma strictum (Hall)

Tremanotus profundus (Conrad)

Many ledges of Deansboro Limestone outcrop north and south of the paved road just east of the intersection 2.7 miles east of Crains Corners. From this locality northward around the end of the hill south of Deck, outcrops of the lower portion of the Deansboro above the Jamesville biostrome are not infrequent. From a hillside ledge southeast of the intersection mentioned above and from exposures in a road cut just east of the intersection, the following fauna was obtained.

Atrypa reticularis (Linnaeus)

Brachyprion varistriata (Conrad)

Gypidula coeymanensis Schuchert

Leptaena rhomboidalis (Wilckens)

Rhipidomelloides oblata (Hall)

Howellella cyclopterus (Hall)

Strophonella punctulifera (Conrad)

Uncinulus sp.

Enterolasma strictum (Hall)

Tremanotus profundus (Conrad)

Exposures of the Deansboro Limestone in the western portion of the quadrangle are somewhat more accessible although usually just as incomplete as those to the east. Several quarries and stream beds in the vicinity of Cullen expose much of the upper half of the Deansboro. This portion of the Deansboro appears to be much less fossiliferous than the lower beds. Fine exposures of the lower portion of the Deansboro and the contact with the underlying Jamesville are well displayed in the Jordanville quarry. *Uncinulus mutabilis* is very abundant in the basal beds of the Deansboro here. *Tremanotus profundus*, *Brachyprion varistriata*, *Gypidula coeymanensis*, and *Atrypa reticularis* were collected also.

The Deansboro Limestone of the Richfield Springs quadrangle has yielded the fauna listed below. This list includes species reported by earlier workers.

BRACHIOPODS

Anastrophia verneuili (Hall)

Atrypa reticularis (Linnaeus)

Brachyprion varistriata (Conrad)

Camarotoechia altiplicata (Hall)

C. semiplicata (Conrad)
Gypidula coeymanensis Schuchert
Leptaena rhomboidalis (Wilckens)
Meristella laevis (Vanuxem)
M. princeps (Hall)
Rhipidomelloides oblata (Hall)
Rhytistrophia beckii (Hall)
Schuchertella woolworthana (Hall)
Howellella cyclopterus Hall
Stropheondonta sp.
Strophonella punctulifera (Conrad)
Uncinulus abruptus (Hall)
U. mutabilis (Hall)
U. nucleolatus (Hall)
U. pyramidatus (Hall)

MISCELLANEOUS

Platyceras sp.
Tremanotus profundus (Conrad)
Dalmanites litchfieldensis Delo
Odontochile micrurus (Green)
Enterolasma strictum (Hall)
Favosites helderbergiae Hall
Syringostroma barretti Girty
Monotrypella ? *abrupta* Hall

This fauna is not greatly different from that of the Dayville Limestone below, nor is any great difference to be expected since both units are composed of similar lithologies of Lower Devonian Helderbergian age. However, several differences of use in distinguishing these limestones in the field are worthy of mention. Deansboro exposures usually contain the gastropod *Tremanotus profundus*, which has not been found in the Dayville. *Gypidula coeymanensis* is found in the Deansboro everywhere across the quadrangle and westward. This brachiopod appears to be lacking in the Dayville west of the ridge between Willse Four Corners and Summit Lake.

Kalkberg Limestone

The highest Helderbergian formation present in the Richfield Springs quadrangle is the Kalkberg Limestone (Chadwick, 1908). No representation of the New Scotland, Becraft, Alsen, or Port Ewen formations — all members of the Helderbergian Series in eastern New

York — has been found. The upper contact of the Helderbergian rocks in this area with the overlying strata is unconformable.

The Kalkberg is composed of thin- to medium-bedded limestones which have moderately irregular bedding planes. It is usually dark blue, finer grained than the Coeymans or Deansboro below and is very siliceous. It weathers light to dark gray and a rusty or yellowish argillaceous coating often forms on the weathered surface. By far the most characteristic features of the Kalkberg are the presence of black chert and the common occurrence of calcareous and argillaceous shales interbedded with the limestones, both of which are lacking in the Coeymans. Across the Richfield Springs quadrangle, the Kalkberg decreases in thickness, largely due to the unconformity at the top with the overlying rocks. About 50 feet are present at the eastern border of the area, but less than 15 feet remain along the western edge of the quadrangle. The Kalkberg grades downward into the Ravena or Deansboro limestones below. As in eastern New York, it is quite fossiliferous.

Outcrops of the Kalkberg in this quadrangle are not so frequent as those in some of the underlying Helderbergian limestones because of the weaker nature of this formation. Most of them are incomplete and lack exposure of the contacts with strata above and below. The Kalkberg is intermittently exposed in the hillside south of the Dugway Gorge, at a point 1.2 miles southwest of Salt Springville. The species listed below were obtained from beds exposed at intervals along an old road up the hillside.

Kozlowskiellina perlamellosa (Hall)

Eatonia medialis (Vanuxem)

Isorthis perelegans (Hall)

Leptaena rhomboidalis (Wilckens)

Meristella arcuata (Hall)

M. laevis (Vanuxem)

M. princeps (Hall)

Platyorthis planoconvexa (Hall)

Rhynchonella ? *formosa* Hall

Schuchertella woolworthana (Hall)

Howellella cyclopterus Hall

Uncinulus mutabilis (Hall)

Aulopora schohariae Hall

Favosites sp.

Perhaps the most continuous exposure of the Kalkberg is that in the ditch along the south side of the second dirt road to the west on the road from East Springfield to Willse Four Corners. The Kalkberg

is exposed in the steep slope between the farmhouse and the sharp northward bend in the road. The faunas listed below were obtained here.

FROM THE BASAL BEDS

- Kozłowskiellina perlamellosa* (Hall)
- Eatonia medialis* (Vanuxem)
- Meristella arcuata* (Hall), very common
- Platyorthis planoconvexa* (Hall)
- Schuchertella woolworthana* (Hall)

FROM HIGHER BEDS

- Kozłowskiellina perlamellosa* (Hall)
- Isorthis perelegans* (Hall)
- Leptaena rhomboidalis* (Wilckens)
- Levenea subcarinata* (Hall)
- Meristella laevis* (Vanuxem)
- Platyorthis planoconvexa* (Hall)
- Rhipidomelloides oblata* (Hall)
- Rhynchonella* ? *formosa* Hall
- Schuchertella woolworthana* (Hall)
- Howellella cyclopterus* Hall
- Strophonella punctulifera* (Conrad)
- Uncinulus nucleolatus* (Hall)
- Tentaculites elongatus* Hall

Elsewhere in this quadrangle the Kalkberg Limestone is poorly exposed, and fossil collecting is much more difficult. Some of these small exposures from which a few fossils have been obtained are located on the northeast corner of the hillside 1.1 miles southwest of Willse Four Corners, above the small patch of woods on the hillside east of Cedar Swamp and south of the dirt road over the hill, in the ditch along Chyle Road at a point 1.5 miles west of the intersection with Route 80 at Van Hornesville, at the road intersection 2.2 miles east of Crains Corners, and in the bed of Ocquionis Creek, 1.6 miles northwest of Cullen.

A quarry just west of the abandoned railroad 0.7 mile north of Cullen apparently displays the Deansboro-Kalkberg contact. The lowest 9 feet of strata in this quarry lack abundant chert beds and are relatively unfossiliferous, similar to the upper Deansboro elsewhere in the quadrangle. In and above a 6-inch sandy layer about midway up the quarry wall, the following assemblage indicates that these higher cherty beds, totaling 7 feet in thickness, should be assigned to the basal Kalkberg.

Camarotoechia altiplicata (Hall)
Isorthis perelegans (Hall)
Leptaena rhomboidalis (Wilckens)
Leptostrophia planulata (Hall)
Meristella arcuata (Hall), very common
M. laevis (Vanuxem)
Platyorthis planoconvexa (Hall)
Rhipidomelloides oblata (Hall)
Howellella cyclopterus Hall
Strophonella punctulifera (Conrad)
Uncinulus sp.
Odontochile micrurus (Green)
Tentaculites elongatus Hall

The Kalkberg Limestone of the Richfield Springs quadrangle has produced the fauna listed below.

BRACHIOPODS

Camarotoechia altiplicata (Hall)
Kozłowskiellina perlamellosa (Hall)
Eatonia medialis (Hall)
Isorthis perelegans (Hall)
Leptaena rhomboidalis (Wilckens)
Leptostrophia planulata (Hall)
Levenea subcarinata (Hall)
Meristella arcuata (Hall), very common at base
M. laevis (Vanuxem)
M. princeps (Hall)
Platyorthis planoconvexa (Hall)
Rhipidomelloides oblata (Hall)
Rhynchonella formosa Hall
Schuchertella cf. *marylandica* Maynard
S. woolworthanus (Hall)
Howellella cyclopterus Hall
Strophonella punctulifera (Conrad)
Uncinulus mutabilis (Hall)
Uncinulus nucleolatus (Hall)
U. pyramidatus (Hall)

MISCELLANEOUS

Odontochile micrurus (Green)
Synphoroides pleuroptyr (Green)
Aulopora schohariae Hall
Favosites sp.
Tentaculites elongatus Hall

Two exposures of the Kalkberg Limestone in the Richfield Springs quadrangle reveal the bentonite bed originally discovered in this formation in the road cut on U.S. Route 20 northeast of Cherry Valley. One exposure is that in the ditch along the south side of the second dirt road to the west on the road from East Springfield to Willse Four Corners. Here, the bentonite consists of 2 inches of soft white clay, 12 feet below the top of the exposure, and probably 20 to 25 feet below the concealed top of the Kalkberg. The second exposure, somewhat farther west, is located in a very small brook descending the slope just west of Route 80, 0.4 mile north of Springfield Four Corners. Only $10\frac{1}{2}$ feet of cherty limestones intervene between the bentonite and the unconformable top of the Kalkberg exposed here.

ULSTERIAN SERIES

THE ULSTERIAN SERIES is represented in the Richfield Springs quadrangle by two rock units — the Esopus and Carlisle Center Shales, in ascending order. The underlying Oriskany Sandstone is absent at all exposures of the Kalkberg-Esopus contact that have been studied and has not been recognized in drill cores. However, one foot of hard, resistant orthoquartzite is exposed in the ditch along the road leading east from Orendorf Corners at the eastern margin of the adjacent Winfield quadrangle. This representation of the Oriskany may extend a short distance eastward into the Richfield Springs quadrangle beneath covering materials. The Schoharie Formation has been studied recently by Goldring and Flower (1942, 1944), Johnsen (1957, 1959), and Johnsen and Southard (1962). West of the Albany quadrangle, Johnsen has subdivided the Schoharie Formation into two members, the Carlisle Center Shale and overlying Rickard Hill Limestone. Johnsen reports less than 1 foot of Rickard Hill Limestone between the Carlisle Center and Onondaga at a point 1 mile south of East Springfield, in a stream near the Oliver Cemetery. Elsewhere in this quadrangle, the limestone member of the Schoharie apparently is absent, for exposures reveal the Onondaga resting directly upon the Carlisle Center.

Esopus-Carlisle Center Shales

These two Ulsterian rock units are considered together because in this quadrangle they comprise a single shale interval between the

limestones of the Helderberg and Onondaga. While both Laskowski (1956) and Johnsen (1957) have been able to distinguish these in the Richfield Springs quadrangle, their separation is neither obvious nor particularly advantageous for the nonprofessional.

The Esopus (Darton, 1894) and Carlisle Center (Goldring and Flower, 1942, 1944) consist of gray or buff weathering, siliceous and calcareous shales, and siltstones. They are unfossiliferous except for the profuse occurrence of *Taonurus cauda-galli*, a worm burrow, in the upper portion.

The Esopus-Carlisle Center enters the quadrangle from the east with a thickness of 40 to 50 feet. This interval is intermittently exposed in the stream 1.5 miles south of Salt Springville and along the hillside 1.2 miles southwest of that village. A stream south of Route 20 just east of East Springfield also contains a somewhat discontinuous section. Sixty feet of buff-weathering shales with abundant *Taonurus* were measured here. The hill between Willse Four Corners and Summit Lake contains about 60 feet of Esopus-Carlisle Center exposed at several localities — along the dirt road to the west on the road from East Springfield to Willse Four Corners, along the hillside at points 1.1 to 1.6 miles southwest of the latter intersection, and above the small patch of woods on the hillside east of Cedar Swamp.

The most continuous exposures of the Esopus-Carlisle Center Shales are those along the road leading to an abandoned quarry 0.4 mile north of Springfield Four Corners and in a road cut just west of the intersection 2.2 miles east of Crains Corners. Forty-eight feet are present in the former, but only 26 feet were measured at the latter locality. Throughout the western portion of the quadrangle, the Esopus-Carlisle Center is not well exposed. A few incomplete sections in ditches along roads and in streams indicate that the thickness of this unit is considerably reduced. Only 15 feet or less can be present along Ocquionis Creek at a point 1.6 miles northwest of Cullen. Exposures in the ditch on both sides of the road just east of Orendorf Corners (Winfield quadrangle) near the western border of the Richfield Springs area display 7 feet of Esopus-Carlisle Center. It is overlain by the Onondaga and underlain by about a foot of tough, resistant orthoquartzite assigned to the Oriskany. This is the first exposure of the Oriskany found west of Cherry Valley. It overlies about 2 feet of cherty limestone, apparently Kalkberg.

The unconformable contact of the Esopus-Carlisle Center with the Kalkberg below is exposed in the small brook descending the hillside just west of Route 80 at a point 0.4 mile north of Springfield Four Corners. The upper contact with the Onondaga above is revealed



FIGURE 9. Contact between Esopus Shale below and Carlisle Center Siltsstone above, road cut along paved road 1.5 miles north-north-east of Cherry Valley, Canajoharie quadrangle.
Photograph by L. V. Rickard

in the abandoned quarry farther up the same hillside. In the quarry floor, phosphate nodules occur along the unconformity at the top of the Carlisle Center.

ERIAN SERIES

THE MIDDLE DEVONIAN ERIAN SERIES, about 2,000 feet of limestones, shales, and sandstones, has been subdivided into three stages. These are, in ascending order, the Southwood, Cazenovia, and Tioughnioga. Formations and members comprising these stages are given in table 1. All the familiar formations of the Hamilton Group are represented, but only the Moscow is easily distinguished from the others. Exposures of these units are most frequent in road cuts, quarries, and stream beds. Some of the more resistant layers appear in ledges along many hillsides, act as cap rocks of waterfalls in streams and form terraces in the higher, more mountainous portion of the area to the south. Contacts of most units are transitional and therefore difficult to map.

Onondaga Limestone

Exposures of the Onondaga Limestone (Hall, 1839), which is about 120 feet thick across the Richfield Springs quadrangle, are very numerous. The Onondaga has been subdivided into several members (Oliver, 1954), useful in mapping the formation in the field and in understanding the stratigraphy of the unit. These members and their approximate thicknesses in the Richfield Springs quadrangle are as follows, in ascending order — the Edgecliff, 20 to 23 feet; the Nedrow, 12 to 15 feet; the Moorehouse, 75 feet; and the Seneca, 6 feet. The lower contact of the Onondaga is unconformable, as previously described. At the top, its contact with the overlying Union Springs Shale is sharp but not disconformable. Outcrops of the basal Edgecliff Member are the most frequent type of Onondaga exposure encountered. The Edgecliff Member consists of massive, gray, coarsely crystalline limestone and white-weathering chert containing an abundance of crinoid columnals, tabulate and rugose corals. Portions of the Edgecliff are coral biostromes. The Nedrow Member

MIDDLE DEVONIAN							EPOCH
ERIAN							SERIES
CAZENOVIA		TIOUGHNIOGA					STAGE
		Hamilton					GROUP
SOUTH- WOOD		Marcellus		Skaneateles	Ludlowville	Moscow	FORMATION
		Otsego Shale		260	Cooperstown Shale		410
		Chittenango Shale		150	Portland Point Limestone		5-6
		Cherry Valley Limestone		5			
		Union Springs Shale		25			
		Seneca Limestone		6			
		Moorehouse Limestone		75			
		Nedrow Limestone		12-15			
		Edgecliff Limestone		20-23			
		ROCK UNIT					

TABLE 1. Classification of Middle Devonian Rock and Time-Rock Divisions

next above is composed, in central New York, of thin-bedded and shaly limestones containing an abundance of platyceratid gastropods in the lower portion. In the Richfield Springs quadrangle, the Nedrow lithology is somewhat obscure, but its fauna has been recognized and collected. The Moorehouse Member, consisting of fine-grained medium gray limestones with shaly partings, is the major chert-bearing portion of the Onondaga. The chert of the Moorehouse is dark gray or black on both fresh and weathered surfaces. Moorehouse exposures are frequent, second only to those of the Edgecliff in abundance. The Seneca Member is but poorly exposed in this area. Here and elsewhere across New York State, the base of the Seneca Member is marked by the Tioga bentonite. Lithologically, the Seneca differs little from the underlying Moorehouse, but faunal changes across the bentonite are sufficient to permit recognition of the Seneca as a distinct member.

At 12 localities in the Richfield Springs quadrangle, there are coral bioherms (true coral reefs) in the Onondaga Limestone. Most of these appear to be mound-like masses of very coarse-grained limestones profuse with corals. These masses extend upward from the Edgecliff into higher Onondaga members and lack distinct bedding planes. A group of three Onondaga bioherms in the vicinity of Mount Tom appear to be the largest and best exposed examples of these reefs. Mount Tom itself is composed of the largest of these resistant coral masses; the others are located short distances to the northwest and southwest of the Mount Tom reef. A second group of three reefs is located along the road about 1.4 miles north of Warren — one east of the paved road and north of the dirt road to the east, the second and third west of the paved road along the first dirt road to the left on the road from Warren. Smaller and less well exposed Onondaga bioherms have been encountered along Shadow Brook 0.2 mile north of the dirt road leading across the East Springfield valley from Continental School, 0.2 mile north of Chyle Road just west of the dirt road to Merry Hill, and beneath and slightly south of the Deck triangulation station on the hill south of Deck.

Exposures of the Edgecliff Member of the Onondaga are frequently encountered along the hillside south of the road from Salt Springville to East Springfield. The greater resistance of the Edgecliff causes this limestone to act as the cap rock of the escarpment along this hillside. One of the most continuous exposures of the Onondaga, exhibiting the basal contact, is that along the small brook beside the Oliver Cemetery 0.8 mile south of East Springfield. Here, 19 feet of Edgecliff has been measured in the waterfall. Eleven feet of Nedrow may be seen above a 4-foot covered interval and a long exposure of Moore-

house occurs farther up the stream bed. Elsewhere in the East Springfield area the Onondaga may be seen in ledges, quarries, and stream beds along the sides and in the bottom of the valley.

The Onondaga Limestone forms the cap rock of the ridge between East Springfield and Springfield. The Edgecliff is well exposed where it wraps around the north end of this ridge. Two small outliers of Edgecliff Limestone are located on the north end of the ridge near the Willse triangulation station. A fine exposure of much of the Onondaga and of its basal contact is exhibited in the active quarries just north of Springfield Four Corners. The section here contains $19\frac{1}{2}$ feet of Edgecliff, $12\frac{1}{2}$ feet of Nedrow, and 25 feet of Moorehouse. From this point northward, the Edgecliff is frequently encountered along the east side of the ridge to Deck, particularly in the areas north of Springfield Four Corners, north and south of Chyle Road, and near the roads east and northeast of Crains Corners. The Moorehouse Member is often exposed on the west side of this ridge in the area between Crains Corners and Warren. Near the western border of the quadrangle, a quarry along the dirt road north of Ocquionis Creek and 1.4 miles north of Route 20 in Richfield Springs exhibits much of the Moorehouse member.

The senior author has not collected fossils from the Onondaga Limestone of the Richfield Springs quadrangle in as much as this formation has been the subject of detailed study in this area and elsewhere by W. A. Oliver, Jr., of the U.S. Geological Survey. The following faunal lists for the Onondaga of the Richfield Springs quadrangle consists of species reported by Oliver (1954, pp. 643-44) and later papers (1956a, 1956b) and additional occurrences discovered by Oliver at later dates and reported to the senior author by letter.

EDGECLIFF MEMBER, BIOSTROMES

CORALS

Favosites basalticus (Goldfuss)

F. emmonsii Rominger

F. epidermatus Rominger

F. turbinatus Billings

Favosites sp.

Coenites sp.

Ceratopora sp.

Syringopora sp.

Heterophrentis prolifica (Billings)

H. sp.

Siphonophrentis gigantea (Leseuer)

Breviphrentis yandelli (Edwards and Haime)

Bethanyphyllum robustum (Hall)

B. sp.

Blothrophyllum promissum Hall

Heliophyllum sp.

Synaptophyllum simcoense Billings

Cystiphyllodes americanum (Edwards and Haime)

C. cf. conifollis (Hall)

BRACHIOPODS

Pentamerella arata (Conrad)

Atrypa reticularis (Linnaeus)

"*Spirifer*" *duodenarius* (Hall)

"*Sp.*" *raricosta* Hall

Ambocoelia umbonata (Conrad)

Meristella sp.

Stropheodonta inequiradiata Hall

Leptostrophia perplana (Conrad)

Schuchertella pandora (Billings)

Chonetes hemisphericus Hall

Rhipidomella sp.

MISCELLANEOUS

Platyostoma turbinata Hall

P. erectum (Hall)

Proetus clarus Hall

Phacops cristata Hall

Odontocephalus selenurus (Eaton)

Fenestella sp.

EDGECLIFF MEMBER, BIOHERM

CORALS

Favosites basalticus (Goldfuss)

Siphonophrentis gigantea (Leseuer)

Bethanyphyllum sp.

Heliophyllum gemmatum Hall

Billingsastraea cf. verneuili (Edwards and Haime)

Synaptophyllum simcoense Billings

Eridophyllum gigas (Rominger)

E. sp.

Cystiphyllodes americanum (Edwards and Haime)

C. sp.

NEDROW MEMBER

BRACHIOPODS

Atrypa reticularis (Linnaeus)

Coelospira camilla Hall
Pentagonia unisulcata (Conrad)
Strophonella ampla Hall
Schuchertella pandora (Billings)
Chonetes mucronatus Hall
Levenia lenticularis (Vanuxem)

MISCELLANEOUS

Heterophrentis prolifica (Billings)
H. sp.
Styliolina fissurella (Hall)
Goldringia trivolvis (Conrad)
Phacops cristata Hall
Ondontocephalus selenurus (Eaton)

MOOREHOUSE MEMBER

BRACHIOPODS

Stropheodonta inequiradiata Hall
Leptostrophia perplana (Conrad)
Leptaena rhomboidalis (Wilckens)
Schuchertella pandora (Billings)
Chonetes hemisphericus Hall
C. lineatus (Conrad)
C. mucronatus Hall
Pentamerella arata (Conrad)
Camarotoechia sp.
Atrypa reticularis (Linneaus)
Coelospira camilla Hall
Anoplothea acutiplicata (Conrad)
Elytha fimbriata (Conrad)
"Spirifer" raricosta Conrad
Nucleospira concinna Hall
Meristella doris Hall
M. sp.
Pentagonia unisulcata (Conrad)
Athyris spiriferoides (Eaton)
Strophonella ampla Hall
Cymostrophia patersoni (Hall)
Productella navicella Hall
Levenia lenticularis (Vanuxem)
Rhipidomella sp.

CORALS

Coenites sp.

Aulopora sp.
Romingeria sp.
Ceratopora sp.
Amplexiphyllum hamiltoniae (Hall)
Heterophrentis prolifica (Billings)
H. sp. A
H. sp. B
Synaptophyllum simcoense Billings

MISCELLANEOUS

Bryozoa spp.
Fenestella sp.
Loxonema sp.
Platyostoma lineata Conrad
Platyceras dumosum Conrad
P. sp.
Hyolithes cf. *striatus* Hall
Coleolus crenatocinctum Hall
Styliolina fissurella (Hall)
Striacoceras typum (Saemann)
Goldringia trivolvis (Conrad)
Phacops cristata Hall
Odontocephalus selenurus (Eaton)
Ostracod spp.
Fish teeth

Union Springs Shale

The Union Springs Member (Cooper, 1930) of the Marcellus formation consists principally of fissile black shales about 25 feet thick overlying the Onondaga Limestone with a sharp but not disconformable contact. Numerous calcareous concretions and thin limestone layers characterize the upper portion. It is gradationally overlain by the thin Cherry Valley Limestone and is lithologically and faunally nearly indistinguishable from the Chittenango Shale above the Cherry Valley. Hence identification of the Union Springs rests primarily upon its stratigraphic position between the Onondaga and Cherry Valley limestones.

Exposures of this soft and readily weathered shale are not frequent in the Richfield Springs quadrangle. In the western portion of this quadrangle, the Union Springs is partially exposed in a small quarry west of the paved road 0.3 mile north of Route 20 and 1.2 miles west of Warren. Several beds of black shale in this quarry produced

fossils. Scattered exposures of black shale have been seen in the ditches along the dirt roads crossing the outlier of Union Springs 1 mile northwest of Springfield Four Corners. The uppermost portion of the Union Springs and its contact with the overlying Cherry Valley may be observed in the exposures along Continental Road.

The most complete section of the Union Springs black shale is that in Cox's Ravine, just south of the paved road 0.6 mile northwest of Cherry Valley. Here, the upper boundary of the Union Springs has been placed at the bottom of the massive limestone layer (basal Cherry Valley) forming the cap rock of the waterfall (Flower, 1943; Rickard, 1952). Below this limestone, $2\frac{1}{2}$ feet of calcareous black shales and thin limestones contain *Agoniatites nodiferus*. The *A. nodiferus* zone is underlain by 17 inches of limestone containing *Cabrieroceras* (formerly *Werneroceras*) *plebeiforme*. Typical Union Springs black shale with limestone concretions follows below and extends downstream for some distance. Thus the top of the Union Springs is here marked by two faunal zones — the *C. plebeiforme* zone (limestone) and, above it, the *A. nodiferus* zone (shale). However, westward across the quadrangle, the upper zone thins and becomes barren of fossils. In the exposures on the southeast side of Pine Cobble Hill, the *Cabrieroceras* zone is only 14 inches below the base of the Cherry Valley, the intervening shales apparently lacking *A. nodiferus*.

The fauna of the Union Springs is a very small one, indicative of the unusual environment in which this shale was deposited. The following species have been obtained at various exposures across the quadrangle.

"Leiorhynchus" limitaris (Vanuxem)

Lunulicardium marcellense (Vanuxem)

Styliolina fissurella Hall

Tornoceras sp.

Cabrieroceras plebeiforme (Hall) at top only

Agoniatites nodiferus (Hall)

Cherry Valley Limestone

Between the fissile black shales of the Union Springs below and the Chittenango above, there is a thin but persistent terrace-forming limestone known as the Cherry Valley (Vanuxem, 1852; Clarke, 1903). The type section of this member of the Marcellus Formation is at the waterfall in Cox's Ravine 0.7 mile northwest of Cherry Valley. It consists of about 5 feet of black, argillaceous limestone marked on

the outcrop by an orange-red iron stain and hackly fracture. It is divisible into two unequal and somewhat massive parts by a layer of shaly limestone or shale containing limestone nodules.

The best exposures of the Cherry Valley Limestone in the Richfield Springs quadrangle are those at the type section, 0.4 mile upstream above the type section where the upper Cherry Valley is exposed, and along Continental Road, at points 0.4 mile north and 1 mile south of Continental School. Most of these outcrops exhibit the full thickness of the Cherry Valley and the basal contact with the underlying Union Springs. Other Cherry Valley exposures are located in a stream just north of the dirt road 1.2 miles east of Shankley Mountain and along the dirt road northwest of the same mountain. All the above outcrops have furnished fossils. Two small exposures in the western portion of the quadrangle serve only to indicate the persistence of this limestone to the west.

The Cherry Valley was formerly known as the "Goniatite" or "Agoniatite" limestone because of its unique assemblage of cephalopods, particularly species of *Agoniatites*. A fauna of about 50 species, over 30 of them cephalopods, has been obtained from the Cherry Valley across New York State (Rickard, 1952, and earlier collectors). In this quadrangle, only the species listed below have been encountered to date.

CEPHALOPODS

- Agoniatites vanuxemi* (Hall)
- Casteroceras alternatum* (Hall)
- Lobobactrites clavus* (Hall)
- Spyroceras geneva* (Clarke)
- Striacoceras typum* (Saemann)
- Tetranodoceras transversum* (Hall)

MISCELLANEOUS

- Aulopora* sp.
- Ambocoelia* cf. *nana* Grabau
- "*Leiorhynchus*" *limitaris* (Vanuxem)
- Macrochilina onondagaensis* Clarke
- Pleurotomaria rugulata* Hall
- Coleolus aciculatum* Hall
- C.* sp.
- Proetus haldemani* Hall

Chittenango Shale

The jet-black and very fissile Chittenango Shale (Cooper, 1930)

overlying the Cherry Valley is about 150 feet thick in the Richfield Springs quadrangle. Its lower contact is sharp but not disconformable. No thin limestone beds similar to those in the upper portion of the Union Springs Shale are found in the base of the Chittenango. Upward, the Chittenango black shale grades into the soft, dark gray shales of the lower Otsego. This gradual change in lithology makes the identification and mapping of the upper boundary a difficult matter. Some assistance is obtained from changes in the fauna of these shales across the contact.

Although predominately of fissile black shale, the Chittenango does contain numerous limestone septaria and smaller calcareous concretions. Upon exposure, the shale crumbles to very thin sheets which "snap and crackle" when stepped on. It is noncalcareous, except in the basal portion near the contact with the Cherry Valley, and is almost barren of fossils. Only *Styliolina fissurella* and small tentaculitids have been found.

The Chittenango is but weakly resistant to weathering and erosion, like the Union Springs below. Yet because of its much greater thickness in this area, it is more frequently exposed than the lower black shale. In general, the Chittenango underlies the lower portion of the steep valley slopes across the southern third of the Richfield Springs quadrangle. A long and nearly continuous section of the Chittenango may be seen in the stream above the bridge on the first dirt road to the west, south of Cherry Valley. The lower portion is well exposed in the stream and its tributaries above Cox's Ravine, northwest of Cherry Valley, and in a ravine south of the dirt road 2.5 miles north of Cherry Valley. Good sections of Chittenango black shale are exposed in the streams descending the east side of the East Springfield valley, particularly the one just north of Briar Hill which farther downstream flows past the Oliver Cemetery. In the west, it is well exposed north of Allen Lake Road along the stream which flows southeastwardly into Otsego Lake. Other isolated stream-bed and road-cut exposures are frequent throughout the quadrangle but usually are too small to be of much value.

Otsego Shale

A sequence of four stratigraphic units overlying the Chittenango Shale in the Chenango and Unadilla valleys, west of the Richfield Springs and Cooperstown quadrangles, comprise the upper members of the Marcellus Formation. These are, in ascending order, the



FIGURE 10. Joints developed in the lower portion of the Otsego Shale, quarry along unpaved road 2.3 miles south of Youngs Lake, Richfield Springs quadrangle, Photograph by L. V. Rickard

Bridgewater Shale, Solsville Sandstone, Pecksport Shale, and Mottville Sandstone (Cooper, 1930, 1933). When traced eastward into the Susquehanna valley, the interval equivalent to the Bridgewater to the west becomes divisible into two parts — “a lower portion characterized by a definite fauna and an upper part which is transitional to the Solsville” (Cooper, 1933, p. 548). Cooper proposed the name *Otsego* for the lower portion with fossils and designated the type section as the “Dugway” on the east side of Otsego Lake. No name was proposed for the upper portion below the Solsville Sandstone and equivalent to the upper Bridgewater to the west. This unnamed portion, “transitional to the Solsville,” has been included by the writer with the true Solsville sandstone above in one unit, mapped as the Solsville Member.

Subdivisions of the Otsego and Solsville Members into smaller units based largely upon upward changes in the lithology of these members are indicated by Cooper (ref. cit., p. 544) and have been recognized in the field in thicknesses approximating those shown by Cooper. Thus the Otsego consists of two units; the Solsville above contains three divisions. The lithology, thickness, and characteristic fossils of each are noted in the tabulation given below.

Solsville C (true Solsville sandstone)		
Massive and resistant, brown-weathering dark gray sandstones and very arenaceous shales, fossiliferous		120 ft.
Solsville B (“transitional”)		
Dark gray, silty, and arenaceous shales, resistant and lumpy, “ <i>Leiorhynchus</i> ” <i>multicostum</i> abundant		130 ft.
Solsville A (“transitional”)		
Dark gray or black, argillaceous, and somewhat fissile shales similar to the lower Otsego		30–40 ft.
Otsego B (upper Otsego)		
Dark gray or brown, arenaceous, and lumpy shales, <i>Mucrospirifer mucronatus</i> , “ <i>Leiorhynchus</i> ” <i>multicostum</i> , <i>Athyris</i> cf. <i>cora</i>		110 ft.
Otsego A (lower Otsego)		
Dark gray or black, argillaceous or silty shales becoming fissile toward the base, “ <i>Leiorhynchus</i> ” <i>multicostum</i> the only fossil found		150 ft.

These subdivisions grade almost imperceptibly into one another and are exceedingly difficult to delineate in the field even in nearly continuous sections. Isolated exposures in road cuts and quarries

can be assigned to one or more of these subdivisions only by close attention to lithological and faunal details and to their apparent stratigraphic positions. Even then errors of some magnitude in their identification and placement in the stratigraphic column may be made.

Several streams descending the hillside east of Otsego Lake expose almost continuous sections of shales and sandstones assigned to the Otsego and Solsville Members. One, located 1.3 miles north of the southern boundary of the Richfield Springs quadrangle, contains exposures of much of the Otsego Member, apparently lacking the top and bottom contacts. A second, 0.8 mile to the south, exposes the upper portion of the Otsego and nearly all the Solsville above. A high waterfall near the top of the hill in this section contains the true Solsville Sandstone. Several road cuts and a quarry exhibit portions of these members at various points along the paved road east of the lake.

In addition to the exposures mentioned above, portions of the Otsego Member may be seen along the new road extending up the north side of the Mohican Canyon at Fivemile Point and in isolated exposures along Route 80 on the west side of Otsego Lake. A quarry on the short dirt road 1.3 miles southeast of the Allen Lake School exhibits part of the lower Otsego. Streams descending the steep slope along the east side of the valley between Hyde Bay and East Springfield may expose the Otsego Member although these have not been investigated for outcrops. Elsewhere in the quadrangle, the Otsego is exposed along East Hill Road south of Cherry Valley and in the road cut on the paved road to Middlefield Center, located a short distance up the hill from the point where this road leaves New York Route 166, south of Cherry Valley.

The type Otsego Member is 256 feet thick (Cooper, 1933, pp. 548-549), and a thickness of 260 feet has been used in making the geologic map. "In the lower portion it is a dark gray, soft crumbly shale becoming harder and sandier, till the upper one hundred feet are mostly sandy mudstone which breaks into thick lumps. In the lower part '*Leiorhynchus*' *multicosta* is the commonest fossil but in the sandier beds a variety of *Spirifer mucronatus* is abundant along with *Chonetes vincinus*, *Athyris* cf. *A. cora*, *Chonetes* cf. *C. coronatus*, *Rhipidomella vanuxemi* and others" (ref. cit., p. 548).

In the Mohican Canyon road cut at Fivemile Point on the west side of Otsego Lake, the junior author collected and identified the following fossils from the upper division of the Otsego shale.

BRACHIOPODS

Athyris cf. *A. cora* Hall, abundant

Chonetes coronatus (Conrad)
C. mucronata Hall
C. setigera (Hall), abundant
 " *Leiorhynchus* " *multicostum* Hall, abundant
Mucrospirifer mucronatus (Conrad), abundant
Rhipidomella vanuxemi (Hall)
Roemerella grandis (Vanuxem)
Stropheodonta demissa (Conrad)

PELECYPODS

Modiomorpha sp.
Palaeoneilo tenuistriata (Conrad)

MISCELLANEOUS

Acleistoceras sp.
Greenops boothi Green
Tentaculites sp.
Conularia sp.

Crinoid columnals and bryozoans also occur but have not been identified due to their poor preservation.

Solsville Sandstone

As used in this report, the term *Solsville* includes the unnamed shales above the Otsego described by Cooper (1933, p. 548) as "transitional to the Solsville" in addition to the true Solsville Sandstone above. Thus defined, the Solsville Member contains three lithological subdivisions, previously described, and totals about 290 feet in thickness. The massive and resistant sandstone at the top (Solsville C) acts as the cap rock of various waterfalls in streams and frequently outcrops in ledges and terraces along the hillsides.

The lower divisions of the Solsville (A and B) are exposed in the stream entering Canadarago Lake from Bailey Pond, in road cuts and quarries on both sides of the hill just south of Allen Lake, and in a quarry 2 miles due south of Allen Lake. In shales at these exposures, the senior author collected the following species.

Chonetes coronatus (Conrad)
 " *Leiorhynchus* " *multicosta* Hall, very abundant
Goniophora hamiltonensis Hall
Paracyclas lirata (Conrad)

Other exposures of the lower Solsville are found in a quarry 0.5 mile north of Pierstown, in the streams descending the hillside east

of Otsego Lake (and possibly also those east of Hyde Bay), and in the upper portion of the stream from the pond on East Hill Road, south of Cherry Valley.

Owing to its much greater resistance, the true Solsville Sandstone (Solsville C) is much more often exposed than the underlying strata of the Solsville or the Otsego. Upper Solsville sandstones and shales are exposed in many ledges on the hillside 0.8 mile north of Rum Hill (Otsego Mt.). *Camarotoechia congregata*, *Ambocoelia umbonata*, and *Actinopteria boydi* were collected by the senior author in this area from the uppermost portion of the sandstone. In a quarry at the top of the Solsville sandstone on the dirt road 1.7 miles west of Rum Hill, the senior author obtained the fauna listed below.

BRACHIOPODS

Ambocoelia umbonata (Conrad), common

Camarotoechia congregata (Conrad)

C. prolifica (Hall)

Chonetes setigera (Hall)

Leptostrophia perplana (Conrad)

Mucrospirifer mucronatus (Conrad)

Productella dumosa Hall

"*Spirifer*" sp.

PELECYPODS

Grammysia sp.

⁴ *Paracyclas lirata* (Conrad), common

Spyroceras sp.

Ledges of Solsville sandstone are common on the hillside west of the paved road 0.5 mile south of Taylortown, and at the upper (north-western) end of Wedderspoon Hollow and a similar unnamed valley next to the south. A small quarry and road cuts at points 0.3, 0.5, and 1.3 miles along the paved road south of Pierstown exhibit portions of the Solsville Sandstone. Exposures in the eastern portion of the Richfield Springs quadrangle are few. In addition to those in the streams east of Otsego Lake, the upper Solsville may be seen in ledges along the hillside 0.7 mile north of Stanley School and at the top of East Hill, south of Cherry Valley.

In the northeastern part of the Cooperstown quadrangle, the transitional nature of the Otsego-Solsville contact can be seen in the stream bed and along the dirt road leading west from Route 166 just north of Roseboom. The contact is also found along the tributary 0.4 mile south-southwest of Roseboom. The same interval is exposed in the bed of a north-flowing stream immediately south of the intersection, 0.6 mile east of Pleasant Brook village. Isolated exposures of the

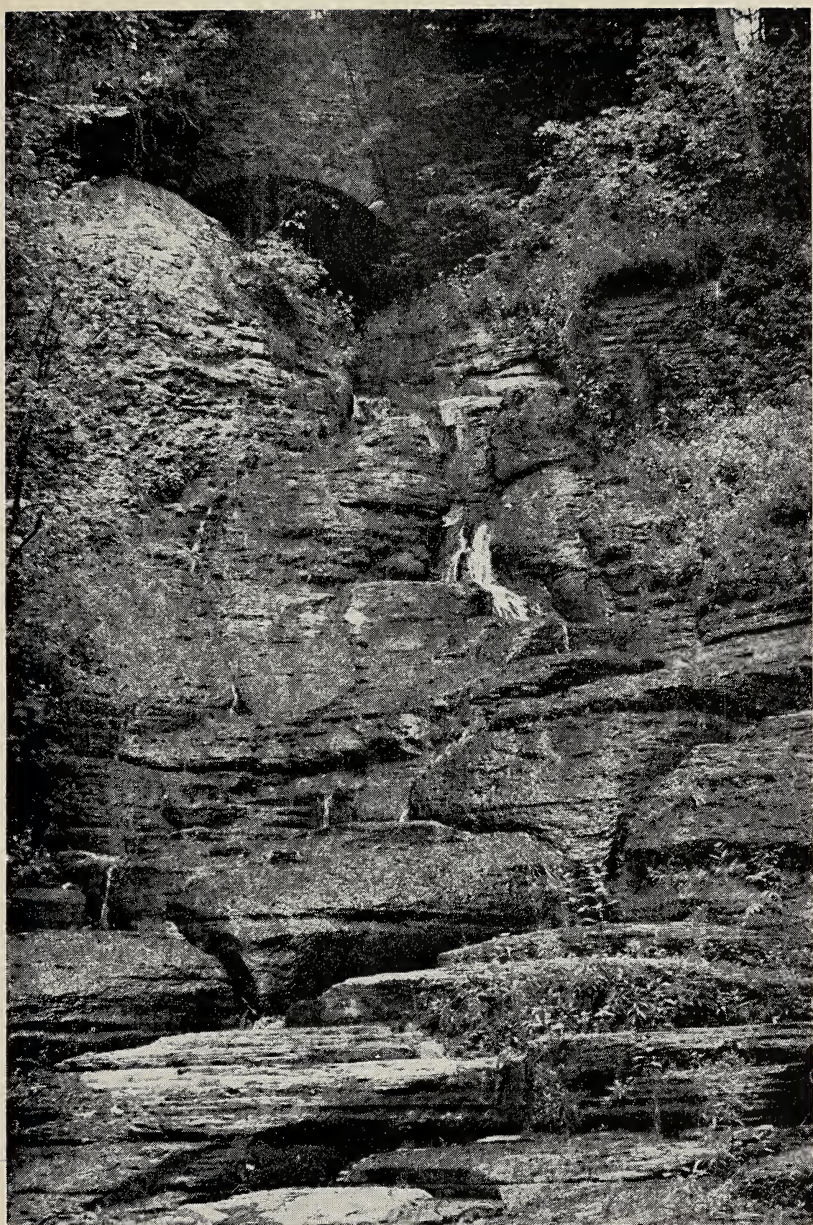


FIGURE 11. Solsville shale and sandstone at Leatherstocking Falls, Cooperstown quadrangle.

Photograph by D. H. Zenger

three units of the Solsville occur at higher elevations along the streams mentioned.

The Solsville Member underlies the lower parts of the hills bordering the southern third of Otsego Lake. More continuous exposures are seen along the road on the east side of the lake. A fine section including parts of the B and C units occurs at picturesque Leatherstocking Falls on the west side of the lake, 2 miles north of Coopers-town.

From an outcrop half a mile south of Three Mile Point along the western side of Otsego Lake, Zenger collected and identified the following species from the lower Solsville shales.

BRACHIOPODS

- Chonetes scitulus* Hall, abundant
- "*Leiorhynchus*" *multicostum* Hall, abundant
- Mucrospirifer mucronatus* (Conrad)

PELECYPODS

- Modiomorpha subalata* var. *chemungensis* (Conrad), abundant
- Nuculana diversa* (Hall)
- Nucula corbuliformis* Hall
- Nuculites oblongatus* Conrad
- Palaeoneilo* sp., abundant

MISCELLANEOUS

- Bembexia capillaria* (Conrad)
- Acleistoceras* ? sp., abundant
- Orthoceras* sp., abundant
- Pleuronotus* aff. *P. decewi* (Billings)

The junior author collected fossils from the upper Solsville in a stream behind a farm 2.1 miles south of Roseboom along New York Route 166.

BRACHIOPODS

- Chonetes scitulus* Hall, abundant
- "*Leiorhynchus*" *multicostum* Hall, abundant
- Mucrospirifer mucronatus* (Conrad)
- Spinocyrtia granulosus* (Conrad)

PELECYPODS

- Actinopteria boydi* (Conrad)
- Cornellites flabella* (Conrad)
- Grammysia circularis* (Hall)

GASTROPODS

Bembexia sulcomarginata (Conrad)

Platyceras sp.

Panther Mountain Formation

Overlying the Solsville is a thick mass of shales and sandstones, lithologically indivisible, totaling 830 feet in thickness (Cooper, 1933, p. 551). This interval includes strata equivalent to the uppermost Marcellus, Skaneateles, and Ludlowville which are undifferentiated owing to the eastward replacement of the Mottville and Centerfield (Stone Mill) members by rocks of sandier facies. Cooper (ref. cit., p. 500) proposed the term "Panther Mountain" for this thick interval of undifferentiated strata and suggested that "this name be used in [the] Susquehanna and Cherry Valleys for the interval between the Solsville and Portland Point members, where the Pecksport and Mottville are lithologically indistinguishable, and the Skaneateles and Ludlowville cannot be separated. . . ."

In the Susquehanna Valley, Cooper found that, although it is possible to distinguish lithologically the lower portion of the Pecksport above the Solsville, the upper boundary is unrecognizable. The lithology of the upper Pecksport is similar to that of the overlying Mottville. Thirty-five or forty feet above the top of the Solsville Sandstone Cooper (ref. cit., pp. 545, 550) discovered a highly fossiliferous zone, 30 to 35 feet thick, containing *Paraspirifer acuminatus* and large specimens of *Tropidoleptus carinatus*. The stratigraphic position of this zone indicated that it was to be correlated with the Mottville. Just above the *Paraspirifer* zone, Cooper found *Pholidops* and *Bembexia sulcomarginata*, guides to the Delphi Station Shale, the lowest member of the Skaneateles Formation. Thus it is possible to determine the top of the Marcellus Formation by faunal criteria although this horizon is lithologically unrecognizable.

In 1933, Cooper included the Mottville in the Skaneateles Formation but later (1942, p. 1772) transferred this member to the top of the Marcellus below. Thus defined, the upper boundary of the Marcellus in this area would be at the top of the *Paraspirifer* zone, and the formation would be about 800 feet thick. If the Mottville *Paraspirifer* zone is added to the thickness of the Marcellus indicated by Cooper (1933, p. 544) in the stratigraphic column for the Susquehanna Valley, a similar figure is obtained. However, in the text on the adjacent page, Cooper estimates the Marcellus (excluding the Mottville) to be 713 feet thick, evidently an error or misprint.



FIGURE 12. Flow roll in Panther Mountain siltstones along New York Highway 7, 1.7 miles west of Worcester, Cooperstown quadrangle. Photograph by D. H. Zenger

Panther Mountain shales and sandstones underlie the uppermost portions of the hills in the southern third of the Richfield Springs quadrangle and extensive portions of the Cooperstown quadrangle. It is fossiliferous and collections have been obtained from several horizons within the unit. Several exposures near the base of the Panther Mountain have yielded faunas indicative of the Mottville horizon. At the top of a small roadside quarry 1 mile south of Pierstown (Richfield Springs quadrangle), the senior author obtained the following species.

BRACHIOPODS

- Camarotoechia congregata* (Conrad), common
- C. prolifica* (Hall), common
- Chonetes coronatus* (Conrad)
- C. scitulus* Hall
- Mucrospirifer mucronatus* (Conrad)
- Paraspirifer acuminatus* (Conrad)
- Tropidoleptus carinatus* (Conrad), large specimens

PELECYPODS

- Actinopteria boydi* (Conrad)
- Cornellites flabellum* (Conrad)
- Grammysia* sp.
- Palaeoneilo* sp.

In the ditch along the west side of the dirt road leading southward up the hill from the intersection 0.7 mile northwest of Rum Hill (Otsego Mountain), the following species were collected by Rickard.

BRACHIOPODS

- Ambocoelia umbonata* (Conrad)
- Camarotoechia congregata* (Conrad)
- C. sappho* (Hall)
- Chonetes coronatus* (Conrad)
- C.* sp.
- Mucrospirifer mucronatus* (Conrad), common
- Paraspirifer acuminatus* (Conrad)
- Rhipidomella vanuxemi* Hall

PELECYPODS

- Actinopteria* sp.
- Goniophora* ? sp.
- Modiomorpha mytiloides* (Conrad)
- Palaeoneilo* sp.
- Paracyclas lirata* (Conrad)

MISCELLANEOUS

bryozoan spp.

crinoid columnals

In a cut for a foundation of a house, 1 mile north of Leatherstocking Falls at the northern edge of the Cooperstown quadrangle, Zenger collected from the Mottville horizon.

BRACHIOPODS

Camarotoechia sappho (Hall)*Chonetes coronatus* (Conrad)*Mucrospirifer mucronatus* (Conrad)*Paraspirifer acuminatus* ? (Conrad)*Platyrachella* aff. *P. mestastrialis* (Hall)*Productella* sp.*Spinocyrtia granulosa* (Conrad)*Tropidoleptus carinatus* (Conrad), abundant

PELECYPODS

Actinopteria boydi (Conrad), abundant*Cypricardella bellistriata* (Conrad)*Glyptodesma erectum* (Conrad)*Leiopteria* sp.*Modiomorpha concentrica* (Conrad)*Nucula corbuliformis* Hall, abundant*Nyassa arguta* Hall*Palaeoneilo* (*Koenenia*) *emarginata* (Conrad)*Paracyclas lirata* (Conrad)*Pseudoaviculopecten princeps* (Conrad), abundant

MISCELLANEOUS

Bembexia sp." *Orthoceras* " sp.

A quarry at the western border of the Richfield Springs quadrangle, 2.1 miles north of the southern boundary, exposes beds about 200 feet above the top of the Solsville sandstone. Here the senior author collected the species listed below.

BRACHIOPODS

Camarotoechia congregata (Conrad), common*Mediospirifer audaculus* (Conrad), common*Leptostrophia perplana* (Conrad), common*Tropidoleptus carinatus* (Conrad)

PELECYPODS

Actinopteria boydi (Conrad)

Goniophora hamiltonensis Hall
Grammysia bisulcata (Conrad)
Modiomorpha mytiloides (Conrad)
Paracyclas lirata (Conrad)

GASTROPODS

Bembexia sulcomarginata (Conrad)
 large unidentified gastropod, common

Other exposures of the Panther Mountain shales and sandstones are located along the hillsides east and north of Twelve Thousand, along the dirt roads on Rum Hill (Otsego Mountain) and Metcalf Hill to the south, and in a small quarry east of Muskrat Pond on Tanner Hill. Two small quarries on Hubbel Hollow Road are the only known exposures of the Panther Mountain in the eastern half of the Richfield Springs quadrangle.

Lower Panther Mountain shales and sandstones crop out on a gently sloping hillside just north of the dirt road, 0.2 mile west of Pail Shop Corners in the northwestern part of the Cooperstown quadrangle. The fauna at this exposure includes "*Leiorhynchus*" *multicostum* and *Tropidoleptus carinatus*. The latter was not found below this stratigraphic position in the Cooperstown area. "*Leiorhynchus*" is a characteristic Marcellus fossil in the eastern outcrop belt of the Hamilton, whereas *Tropidoleptus* is more commonly found in the coarser phases. The association of these two brachiopods was not observed above or below this horizon in the mapped area. The stratigraphic position of this outcrop must be near the Marcellus-Skaneateles boundary, as suggested by the presence of these fossils.

An abandoned quarry just west of the main road 1.75 miles north of the village of Fly Creek, Cooperstown quadrangle, exposes a sequence of thin-bedded, arenaceous shales, flaggy siltstones, and gray, argillaceous sandstones. These beds are lower Skaneateles in age. Zenger collected the following fossils at this location:

BRACHIOPODS

Camarotoechia sappho (Hall), common
Chonetes scitulus Hall
C. setigera Hall
Mucrospirifer mucronatus (Conrad), abundant
Spinocyrtia granulatus (Conrad)
Tropidoleptus carinatus (Conrad)

PELECYPODS

Actinopteria boydi (Conrad)
Cypricardella bellistriata (Conrad)

Glyptodesma erectum (Conrad)
Goniophora hamiltonensis (Hall)
Gosselettia triquetra (Conrad)
Grammysia bisulcata (Conrad)
G. arcuata (Conrad)
Nuculites oblongatus Conrad
Palaeoneilo tenuistriata (Conrad)
Paracyclas lirata (Conrad)
Pseudaviculopecten cf. *P. princeps* (Conrad)
Sphenotus sp.

MISCELLANEOUS

Dipleura dekayi Green

"*Orthoceras*" sp.

molds of crinoid stems; plant fragments

A nearly continuous section of about 150 feet of the Panther Mountain Formation is exposed along the dirt road and in the quarry near the top of the hill just east-northeast of Cooperstown. The sequence, lower Skaneateles in age, shows the complex variations in clastic lithologies which are characteristic of the Panther Mountain shales and sandstones.

An excellent section of part of the Panther Mountain Formation is provided by the road cut along Route 80, 1 mile west of Cooperstown. The lithologies include bluish-gray, silty shales intercalated with thin, irregularly bedded argillaceous sandstones, and thicker-bedded, brownish-gray, fine-grained sandstones. (A thin section of a specimen from one of the sandstone beds shows the characteristically well-sorted but angular quartz grains, in the range of .1-.2 mm., making up about 70 per cent of the rock.) Concretionary layers and thin coquinites are common. The latter probably represent times when little was accumulating other than fossil debris. The sequence is upper Skaneateles in age. Here, Zenger collected the following:

BRACHIOPODS

Mediospirifer audaculus (Conrad)
Camarotoechia eximia Hall
C. orbicularis Hall
C. sappho (Hall), abundant
Chonetes coronatus (Conrad)
Cyrtina hamiltonensis (Hall)
Mucrospirifer mucronatus (Conrad)
Tropidoleptus carinatus (Conrad)

PELECYPODS

- Actinopteria boydi* (Conrad), abundant
Cypricardella complanata Hall
Goniophora hamiltonensis (Hall)
Grammysia bisulcata (Conrad)
G. elliptica Hall
Leiopteria dekayi Hall
L. cf. L. conradi Hall
Nucula corbuliformis Hall
Nyassa arguta Hall
Palaeoneilo emarginata (Conrad)
P. plana Hall
Paracyclas lirata (Conrad)
Pseudaviculopecten princeps (Conrad)

MISCELLANEOUS

- Bembexia* sp.
Hederella sp.
Tentaculites sp.
 molds of crinoid stems; encrusting bryozoans

It is interesting to note that a few pelecypods including *Paracyclas lirata*, *Bembexia sulcomarginata*, and a brachiopod similar to *Platyrachella mesastrialis* occur in the Skaneateles and Marcellus portions of the Panther Mountain Formation. Apparently, these forms are absent in the overlying Hamilton at this meridian. However, they reappear in the Taghanic Stage (see also Cooper, 1934, p. 9).

There are exposures of the upper (or Ludlowville-equivalent) Panther Mountain too numerous to mention. Most of these occur in the central third of the Cooperstown quadrangle. The more common fossils collected from this interval are:

BRACHIOPODS

- Athyris spiriferoides* (Eaton)
Camarotoechia eximia Hall
C. sappho (Hall)
Chonetes coronatus (Conrad)
C. scitulus Hall
C. setigera Hall
Cyrtina hamiltonensis (Hall)
Mediospirifer audaculus (Conrad)
Mucrospirifer mucronatus (Conrad)
Paraspirifer cf. P. acuminatus (Conrad)
Spinocyrtia granulosus (Conrad)

Tropidoleptus carinatus (Conrad)

PELECYPODS

Actinopteria boydi (Conrad)*Aviculopecten* sp.*Cypricardella bellistriata* (Conrad)*Glyptodesma erectum* (Conrad)*Goniophora hamiltonensis* (Hall)*Gosselettia triquetra* (Conrad)*Grammysia bisulcata* (Conrad)*G. elliptica* Hall*Grammysioides alveata* (Conrad)*Leiopteria dekayi* Hall*Leptodesma* sp.*Modiomorpha concentrica* (Conrad)*M. mytiloides* (Conrad)*M. cf. M. subalata* (Conrad)*Nucula corbuliformis* Hall*Nuculites oblongatus* (Conrad)*Orthonota undulata* (Conrad)*Palaeoneilo emarginata* (Conrad)*P. muta* Hall

MISCELLANEOUS

Dipleura dekayi Green*Bembexia capillaria* (Conrad)

tentaculitids; molds of crinoid stems, bryozoans, and plant fragments

The Panther Mountain contains structures such as joints, concretionary beds, flow rolls, cross-stratification, and ripple marks.

Flow rolls, also called storm rollers, are most common in fine-grained sandstone beds. These contorted structures were also found in thin-bedded siltstone beds. The flow-roll beds observed range from 1 foot to 8 feet in thickness. The underlying and overlying strata are undisturbed, and the contacts are commonly very distinct. Where flow rolls occur in thin-bedded siltstones, the appearance resembles spheroidal weathering. A fine example can be seen on the north side of Route 7, 1.7 miles southwest of Worcester, Cooperstown quadrangle (figure 12).

Similar deformed beds of various ages occur elsewhere. Although many may owe their origin to storm action, it is believed that these Devonian flow rolls resulted from penecontemporaneous slump (Dunbar and Rogers, 1957, pp. 192-193).

Portland Point Limestone

The Moscow Formation may be considered as an appropriate stratigraphic designation in the Cooperstown quadrangle. It consists of two members which are mappable units. The lower member, the Portland Point Limestone, can be traced from its type section at Cayuga Lake eastward through the Cooperstown quadrangle to Greene County, where it disappears. Its stratigraphic position farther east is occupied by continental beds.

The Portland Point averages 6 feet in thickness at this meridian. The lower contact with the Panther Mountain shales and sandstones is abrupt, both lithologically and faunally. Its greater resistance than the subjacent and superjacent shales results in small waterfalls in many of the streams. The name "limestone" is somewhat misleading. Petrographically, the Portland Point is a dark bluish-gray, massive, resistant, arenaceous biocalcarenite. Calcite grains representing broken crinoid columnals and plates are numerous and are the dominant feature in a hand specimen. In places, the fossil fragments attain a conglomeratic grain size. Two thin sections of the Portland Point reveal the presence of fine sand-size quartz grains making up about 5 per cent of the rock. Intercalated with the biocalcarenite are thin layers of calcareous shale. Eastward, along Schenevus Valley, noncalcareous layers increase and the massive character is in part replaced by thin bedding. In Schoharie Valley to the east, the Portland Point is a marine quartz-pebble conglomerate. Beyond this point, the unit passes into red beds (Cooper, 1934, p. 1).

Nonrestricted Hamilton fossils, such as *Modiomorpha*, *Goniophora*, and *Chonetes*, are present in the Portland Point. In addition, the two brachiopods *Centronella impressa* and *Pustulatia pustulosa* are characteristic. The latter fossils are not found immediately above or below. Their presence combined with the distinct lithology serves to clearly define the member. *Cranaena* and *Rhipidomella*, although not restricted to the Portland Point, are most abundant in it.

The best exposures of the Portland Point Member are in the southwestern quarter of the quadrangle, particularly in the lower parts of the tributary valleys near Milford and Westville.

The following fossils were collected from a ledge just off the south end of the bridge over Hinman Hollow Brook, one-third of a mile northwest of Milford, at an elevation of about 1,320 feet.

BRACHIOPODS

Mediospirifer audaculus (Conrad)

Centronella impressa Hall, common

Chonetes coronatus (Conrad)
Cranaena romingeri? (Hall)
Lingula punctata Hall
Mucrospirifer mucronatus (Conrad)
Pustulatia pustulosa (Hall), common

PELECYPODS

Goniophora hamiltonensis (Hall)
Modiomorpha concentrica (Conrad)
M. mytiloides (Conrad)
Pterinopecten sp.

MISCELLANEOUS

Conularia sp.
Sulcoretepora sp.
bryozoan spp.; crinoid fragments

The Portland Point is well exposed at an elevation of about 1,540 feet along the stream just west of Platt Hollow Road, 1.1 miles south of Westville; also at 1,580 feet along the stream draining Moss Pond on the east side of Susquehanna Valley, 1.5 miles east of Hartwick Seminary. The thinner-bedded facies of the eastern part of the map area crops out in the face of the spur along the north side of Route 7, 1.5 miles east of Schenevus.

Cooperstown Shale

The uppermost member of the Moscow Formation in the Cooperstown quadrangle is equivalent to the Windom Shale. Previously, the name "Windom" has been applied at Cooperstown and as far east as Schoharie County, to the interval of silty shales, siltstones, and sandstones of the Hamilton above the Portland Point Limestone. This "Windom" bears little resemblance to the typical calcareous shales of the true Windom of central and western New York. For the eastern, coarser facies of the Windom, the name *Cooperstown* is proposed. The geographic extent of this lithogenetic unit is from Cortland County to Schoharie County, where it grades laterally into continental beds.

Exposures of the Cooperstown are numerous. The composite sections along the stream west of Platt Hollow Road and in Strong Ravine, 1.0 mile south and 2.7 miles south-southwest of Westville, respectively, provide a good type section. The lower, distinct contact with the Portland Point Limestone (at about 1,540 feet) and

the lower part of the Cooperstown are exposed in the stream 1 mile south of Westville. The upper part of the Cooperstown and the contact with the overlying Gilboa Formation (at about 1,755 feet) are exposed in Strong Ravine. The thickness of the member approximates 410 feet. The various lithologies include bluish-gray and brown silty shales; thin-bedded siltstone, in places flaggy; argillaceous, fine-grained sandstones; and leached coquinite beds similar to those in the Panther Mountain Formation. Some beds contain calcite cement. Lithologically, the Cooperstown resembles the other Tioughniogan and Taghanican units in the area, with the exception of the Portland Point.

Structures include flow rolls, joints, and ripple marks. Concretionary layers and cross-stratified beds are not so common as in the Panther Mountain shales and sandstones.

Fossils are very abundant, and most are apparently unrestricted stratigraphically. As in other Hamilton units, brachiopod and pelecypod species constitute the greatest part of the assemblages. It is possible that Cleland's *Ambocoelia* zones (1903) at Cayuga Lake are represented by the occurrence of *Ambocoelia* in the lower half of this member. If so, the zones are not clearly defined. The *Pustulatia* zone (Cooper, 1934) is definitely present in the uppermost layers. Within this zone is a persistent 2- to 3-foot interval containing *Pustulatia pustulosa*. This "*Pustulatia* bed" is very important in delimiting the Cooperstown-Gilboa contact. The *Pustulatia* zone does not occur west of Cayuga Lake, and the progressive loss of older Windom faunal zones west of that point suggests an unconformity at the top of the Hamilton west of Otisco Lake (Cooper, 1933, pp. 541-542). The junior author found no indication of a time break above the Hamilton in the Cooperstown area.

Some of the numerous, fossiliferous outcrops within the Cooperstown Member are as follows:

Lower half of member

- a. Along Platt Hollow Road, 1.5 miles south of Westville
- b. Along first rise in road west from Route 28, 1 mile north of Milford
- c. On north side of Wall Street Road just west of sharp turn south, 3 miles north-northwest of Worcester
- d. Outcrop east of road leading north from eastern part of Schenectady, just north of Route 7

Upper half of member

- a. Abandoned quarry on north side of Hinman Hollow Road, 1 mile northwest of School No. 12, just off west margin of map, on Hartwick quadrangle

- b. Ledges along west side of Morehouse Brook at about 1,340 feet, just north of bridge on Platt Hollow Road, 1 mile north-northwest of Maryland
- c. Abandoned quarry on west side of Platt Hollow Road, 2.1 miles south of Westville

The most accessible location at which to examine the *Pustulatia* bed is adjacent to a culvert on the south side of the road leading up South Hill, opposite Schenevus, at an elevation of about 1,450 feet.

Because most of the fossils are not restricted stratigraphically, species found at the individual sites will not be enumerated. A composite list of the more characteristic ones is presented below.

BRACHIOPODS

- Ambocoelia umbonata* (Conrad)
- Athyris spiriferoides* (Eaton)
- Camarotoechia sappho* (Hall)
- Centronella impressa* Hall
- Chonetes coronatus* (Conrad)
- C. cf. C. lepida* Hall
- C. scitulus* Hall
- C. setigera* Hall
- Cranaena romingeri* ? (Hall)
- Cyrtina hamiltonensis* (Hall)
- Elytha fimbriata* (Conrad)
- Lingula alveata* Hall
- Mediospirifer audaculus* (Conrad)
- Mucrospirifer mucronatus* (Conrad)
- Paraspirifer acuminatus* (Conrad)
- Platyrachella* ? sp.
- Pustulatia pustulosa* (Hall)
- Rhipidomella vanuxemi* (Hall)
- Spinocyrtia granulosa* (Conrad)
- Stropheodonta demissa* (Conrad)
- Tropidoleptus carinatus* (Conrad)

PELECYPODS

- Aviculopecten* sp.
- Cypricardella bellistriata* (Conrad)
- C. tenuistriata* (Hall)
- Glyptodesma erectum* (Conrad)
- Goniophora hamiltonensis* (Hall)
- Gosseletia triquetra* (Conrad)
- Grammysia arcuata* (Conrad)
- G. bisulcata* (Conrad)

G. elliptica Hall
Leiopteria dekayi Hall
L. sp.
Leptodesma sp.
Modiomorpha arcuata Hall
M. concentrica (Conrad)
M. mytiloides (Conrad)
Nucula bellistriata (Conrad)
N. opima (Hall)
Palaeoneilo constricta (Conrad)
P. emarginata (Conrad)
P. maxima (Conrad)
P. plana Hall
P. tenuistriata (Conrad)
Sphenotus sp.
Vertumnia aff. V. reversa (Hall)

BRYOZOANS

Rhopolonaria sp.
Taeniopora exigua Nicholson
 other bryozoan spp.

GASTROPODS

Bellerophon sp.
Bembexia capillaria (Conrad)
Pleurotomaria sp.

TRILOBITES

Dipleura dekayi Green
Greenops boothi (Green)

MISCELLANEOUS

Conularia sp.
Hyolithes sp.
 " *Orthoceras* " sp.
Tentaculites sp.
 crinoid molds; plant fragments; "worm tubes"

SENECAN SERIES

THERE IS a difference of opinion as to the position of the Erian-Senecan boundary in the marine section in western New York.

Recent statements regarding this Middle-Upper Devonian contact have placed it at the base of the Genundewa Limestone (Cooper and others, 1942, p. 1762), below the top of the underlying Geneseo (J. W. Wells, personal communication), and, most recently, at the base of the Tully Limestone (House, 1962, pp. 255-256). The position advocated by House, based upon the occurrence of *Pharciceras amplexum*, is adopted here. Cooper and Williams (1935, p. 829) regarded the Gilboa Formation as being equivalent to the Tully and all or part of the Geneseo. In the Cooperstown quadrangle, however, the top of the Tully equivalent is indeterminable. Here, the Senecan Series consists of two formations, the Gilboa and Oneonta. The former is fossiliferous, of marine origin, whereas the latter is composed predominately of beds of nonmarine origin.

Gilboa Formation

Cooper (1934, p. 7) named the Gilboa beds from exposures on the west face of Reed Hill near Gilboa Reservoir in Schoharie County. The present authors consider the Gilboa Formation as embracing the rocks between the Hamilton Group and the Oneonta Formation. No lithologic or faunal subdivision of this 460-foot unit seems justifiable. Structures and lithologies are similar to those in the Cooperstown Member and the Panther Mountain Formation. Flow rolls, joints, cross-stratification, ripple marks, and small faults were observed. Examples of the various lithologies are: thin-bedded, arenaceous shales; thin-bedded, fine-grained, argillaceous sandstones, some possessing cross-stratification and flaggy parting; medium- to thick-bedded, fine-grained sandstones, commonly in the form of flow rolls. Compact, bluish-gray shales with minor sand content are present sporadically in the uppermost layers of the formation immediately below the Oneonta contact.

There are some outcrops of bluish-gray, flaggy, medium- to coarse-grained, unfossiliferous sandstone. These may represent "non-marine" tongues — the similarity to the Oneonta is striking.

Thin sections of selected sandstones and siltstones of the Gilboa showed angular quartz grains, in the fine sand-size range, comprising 60 to 70 per cent of the specimens. An argillaceous matrix makes up 20 to 30 per cent. These rocks are petrographically classed as quartz wackes (Williams, Turner, and Gilbert, 1955, p. 292-293). Almost the same composition was noted as in thin sections of sandstones and siltstones from the Hamilton units.

The Gilboa is relatively less fossiliferous than the underlying units. The fauna, however, is critical in correlating with sections to the west and also in delimiting the Cooperstown-Gilboa contact.

"*Leiorhynchus*" *mesacostalis* occurs at the base of the formation and higher. It marks the first observed appearance of "*Leiorhynchus*" above the Marcellus at this meridian. *Hypothyridina venustula*, the Tully guide fossil, appears sporadically in layers 40 to 50 feet above the base of the formation. This brachiopod is quite abundant in the southwestern part of the map area. It was traced, in its stratigraphic position, along the northwestern side of Crumhorn Mountain to an elevation of about 1,600 feet. One specimen, in a piece of float, was found in the stream bed just north of Dog Hill, northwest of Schenevus. Cooper (1934, p. 3) did not find *Hypothyridina* east of Schenevus although he made a thorough search. Commonly associated with *Hypothyridina* are *Allanaria tullius*, *Paracyclas lirata*, and *Actinopteria boydi*.

The beds immediately above the *Hypothyridina* zone are sparsely fossiliferous. Above this relatively barren sequence occurs an assemblage typified by *Platyrachella mesastrialis*, *Paracyclas lirata*, and species of *Bembexia*. These forms are found with *Hypothyridina* in the lower beds mentioned, but are more numerous in this higher position. They are elements of the Ithaca, or actually pre-Ithaca, fauna of Cooper and Williams (1935, p. 826). The fact that this fauna appears higher to the west obviously reflects the phase regression in that direction.

The Cooperstown-Gilboa boundary is essentially a faunal one. The fossils were important in mapping this contact. The lowest occurrence of "*Leiorhynchus*" *mesacostalis*, commonly in a flow roll, was assumed to represent the base of the Gilboa (Cooper, 1934, p. 3). "*Leiorhynchus*" is not abundant everywhere at this horizon, especially in the eastern part of the map area. Cooper (1934, p. 3) stated that "*Leiorhynchus*" had been definitely traced as far east as Schenevus and was "recognized" farther east. The junior author found the brachiopod in a stream section near Simpsonville in the southeastern corner of the quadrangle, indicating the extent of the fossil through the area.

The *Pustulatia* bed is the most important datum plane used to establish the top of the Hamilton in the Cooperstown quadrangle (Cooper, 1934, p. 3). The abundance of the fossil and its restriction to a small stratigraphic interval make it ideal for such use. Fortuitous exposures of rocks at this horizon facilitated mapping. Where *Pustulatia* and "*Leiorhynchus*" occurred in the same section, they were invariably between 40 and 60 feet apart stratigraphically. In the south-

eastern part of the quadrangle, where it was often impossible to find "*Leiorhynchus*," an arbitrary 50 feet was added to the elevation of the 3-foot *Pustulatia* bed, and the resulting elevation was taken as an approximate Cooperstown-Gilboa boundary.

In Otego Valley, about 6 miles west of Susquehanna Valley, the Taghanic Stage is divisible into the New Lisbon, Laurens, and "West Brook" shales and sandstones. Those units comprise a clastic facies of the Tully Limestone farther west in New York State. Three faunal zones are used to distinguish the Tully equivalent of Otego Valley, as well as to the west (Cooper and Williams, 1935, pp. 785; 811-812). The *Pustulatia* zone in the uppermost Cooperstown has been described. The *Hypothyridina* zone, in Otego Valley, occurs in the basal part of the Laurens Member (Cooper, 1934, p. 5). Contact with the overlying Unadilla Formation is defined by the *fimbriata* zone (Cooper and Williams, 1935).

The *fimbriata* zone was not found in the Cooperstown quadrangle, however. Thus, although the association of *Hypothyridina* and "*Leiorhynchus*" probably represents an equivalence to the New Lisbon and/or Laurens members of Otego Valley (Cooper and Williams, 1935, p. 814), no upper limit of the unit was recognized; i.e., no demarkation could be made between the Tully equivalents and the Unadilla Formation. The entire sequence, then, from the Cooperstown Member to the Oneonta Formation, is appropriately called "Gilboa Formation." This extends application of the name to areas west of the original definition (Cooper, 1934, p. 7; Cooper and Williams, 1935, p. 829).

The Laurens-equivalent part of the Gilboa is exposed along both sides of Goodyear Lake in the southwestern corner of the map. The fossils most characteristic of this sequence include *Hypothyridina venustula*, *Alanaria tullius*, *Actinopteria boydi*, and *Paracyclas lirata*.

The following collection was taken from the Gilboa outcrop along the South Hill Road opposite Chaseville at about 1,700 feet.

BRACHIOPODS

Camarotoechia eximia Hall

C. sappho (Hall)

Chonetes scitulus Hall, common

"*Leiorhynchus*" *mesacostalis* (Hall)

Mucrospirifer mucronatus (Conrad), common

Platyrachella mesastrialis (Hall), common

Tropidoleptus carinatus (Conrad), common

PELECYPODS

Actinopteria sp.

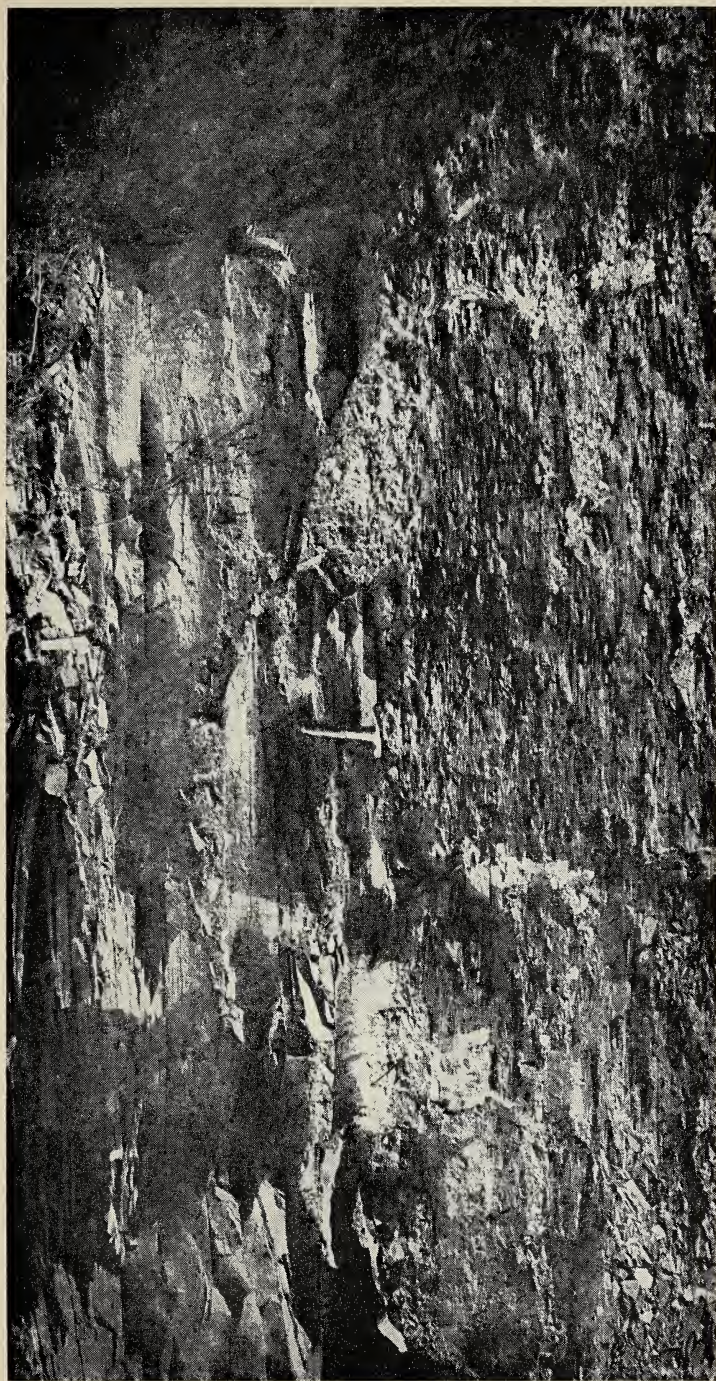


FIGURE 13. Contact between Gilboa (below) and Oneonta (above) Formations, abandoned quarry on South Hill, Cooperstown quad-
range.
Photograph by D. H. Zenger

Goniophora hamiltonensis (Hall), common

Leiopteria sp.

Modiomorpha mytiloides (Conrad)

Nucula corbuliformia Hall

Palaeoneilo emarginata (Conrad)

Paracyclas lirata (Conrad)

MISCELLANEOUS

Bembexia capillaria (Conrad)

Tentaculites cf. *T. attenuatus* Hall

molds of crinoid columnals; bryozoans

A typical group of "Ithaca" fossils were collected from an abandoned quarry near the summit of Dog Hill, 2 miles northwest of Schenectady, at an elevation of about 2,200 feet. The stratigraphic position is in the Gilboa just below the contact with the Oneonta.

BRACHIOPODS

Camarotoechia eximia Hall

Chonetes scitulus Hall

Mucrospirifer mucronatus (Conrad), common

Platyrachella mesastrialis (Hall), common

Tropidoleptus carinatus (Conrad), common

PELECYPODS

Nucula corbuliformis Hall, common

Palaeoneilo constricta (Conrad)

P. maxima (Conrad)

Paracyclas lirata (Conrad)

MISCELLANEOUS

Bembexia sp.

Dipleura dekayi Green

Tentaculites sp.

crinoid stem molds; numerous plant fragments

Oneonta Formation

The rocks overlying the Gilboa Formation in the Cooperstown quadrangle are greenish-gray, fine- to coarse-grained, thin- to medium-bedded sandstones and intercalated arenaceous shales. These beds belong to the "Oneonta sandstone" of Vanuxem (1841, p. 381), named from outcrops on the hills near the city of Oneonta. About 200 feet of the Oneonta occur in the Cooperstown quadrangle, capping most of the hills in the southern part of the area.

Flaggy parting as well as cross-stratification of both the lenticular and tabular type are characteristic of this formation.

The basal Oneonta beds are not red and the term "formation" seems more appropriate than "red beds," a name commonly used. Similar coarse lithologies, perhaps representing nonmarine tongues from the east, were observed within the dominantly marine Panther Mountain and Gilboa Formations. No marine rocks were noted in the lower Oneonta sequence.

The one thin section studied consisted of the following:

Quartz — 55 per cent

Argillaceous matrix — 30 per cent

Chlorite — 5 per cent

Hematite cement — 5 per cent

Minor: Muscovite, biotite, feldspar, zircon, and pyroxene

Long described as nonmarine, the Oneonta was considered by Cooper (1957, p. 264) to be fluvial-lagoonal-littoral.

The lower contact with the Gilboa, where exposed, is distinct and nongradational (figure 13). There is no physical evidence of a disconformity in spite of this very sharp contact. Plant remains constitute the only organic matter found. *Amnigenia*, the fresh-water pelecypod characteristic of the Oneonta, was not observed in these lower beds.

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BULLETIN NUMBER 397

NEW YORK STATE MUSEUM AND
SCIENCE SERVICE

ALBANY, NEW YORK

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Pollen Studies in the Crusoe Lake Area of Prehistoric Indian Occupation¹

by Donald D. Cox²
and Donald M. Lewis

ABSTRACT

Pollen diagrams were constructed for three stations in north central New York State and correlations with previous diagrams were made. A late-glacial phase of the diagram at Crusoe Lake was suggested and tentatively correlated with Deevey's L zones in Maine. Zone L1 was characterized by low spruce, high pine, and high NAP. Zone L2 was identified by a drop in pine and NAP with a rise in spruce and zone L3 by the return of pine and NAP with a drop in spruce. These were interpreted as representing cold to warmer to cold climatic oscillations associated with pre-Valders ice retreat, Two Creeks interstadial, and Valders ice advance. Postglacial zones A1, A2, and A3 were recognized by a high NAP frequency, a spruce peak, and a fir peak respectively. The Boreal Pine zone was identified at site II, but was missing from the truncated site III profile and was missing or greatly abbreviated at site I. The C zones were similar to those identified by other workers for central New York State: A *Tsuga* peak with rising *Fagus* and high *Quercus* in C1; a *Tsuga* minimum and a *Carya* maximum in C2; a return to *Tsuga* in C3. Subzones C2a, C2b, and C2c were suggested by an older *Tsuga* minimum, a secondary rise in *Tsuga*, and a younger minimum respectively. A correlation with a Late Middle Woodland Indian culture was attempted.

¹ Manuscript submitted for publication November 4, 1964

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Introduction

The present study was undertaken to reconstruct vegetational and climatic events through late-glacial and postglacial time to the present and to correlate this information with the archeology of the region under investigation.

Pollen analysis, as a research method, particularly lends itself to the accomplishment of the first part of this objective. It is felt that a high degree of success was achieved in this phase of the work. The second part, however, offered more of a challenge to palynological methods and its realization was much less certain. Particular attention was given to the possible detection of concentrations of *Zea* (corn or maize) and other Indian food plant pollens at points in the profiles. Further, attempts were made to recover pollen from soil samples taken from an archeological trench at an Indian campsite. Neither of these procedures proved entirely successful. No *Zea* pollen was identified in any of the profiles of the present study. It was hoped that if the Indians who occupied the sites surrounding the sample area had ever practiced the cultivation of corn, this would be reflected in the pollen profile. Soil samples taken by William A. Ritchie and Harold Secor from a trench near the Savannah site were processed for pollen content. The intent here was to get a pollen count that could be correlated with some level in the pollen profiles. These efforts were successful to a degree, but the results are far from conclusive.

Acknowledgments

The authors gratefully acknowledge the very valuable assistance and cooperation given by the following people: Herbert L. Anderson, Mayor, City of Auburn; Dr. Clair A. Brown, Professor of Botany, Louisiana State University; Dr. Donald L. Collins, Director of the Biological Survey, New York State Museum and Science Service; Charles Drummond, owner of the Crusoe Lake property; Dr. Chauncey D. Holmes, Emeritus Professor of Geology, University of Missouri; Dr. Eugene C. Ogden, State Botanist, and Dr. William A. Ritchie, State Archeologist, both of the New York State Museum and Science Service; Harold Secor, Mayor, Town of Savannah; Stanley J. Smith, Curator of Botany, New York State Museum; and James Street, Geology Department, Syracuse University. The authors are especially grateful to Dr. Edward S. Deevey, Professor of Biology, Yale University, and to Dr. Ernest Muller, Professor of Geology, Syracuse University, for reading the manuscript and offering many helpful suggestions.

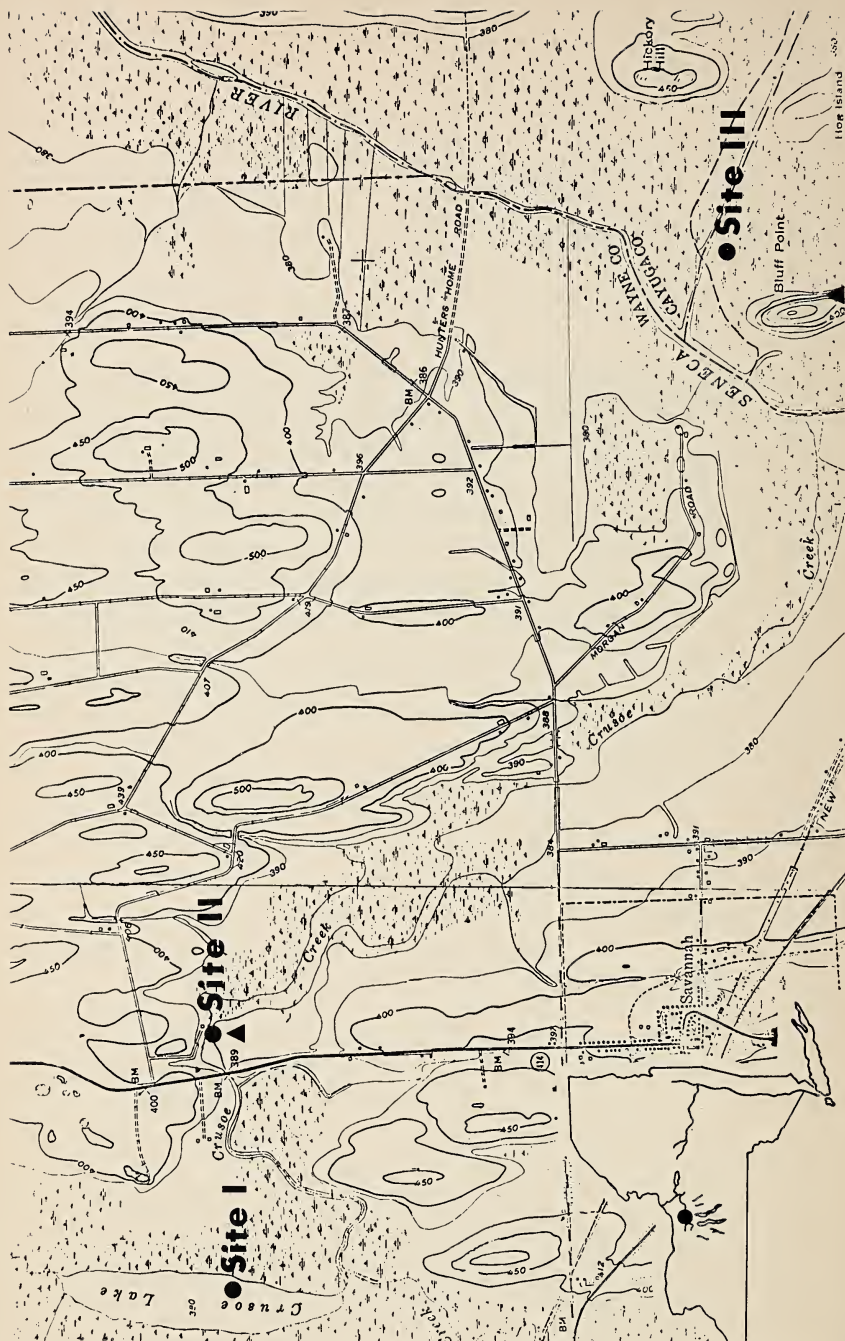


FIGURE 1. Location of pollen sampling sites ● and archeological sites ▲ in the Crusoe Lake area.

LOCATION AND DESCRIPTION OF SITES

Samples were taken from three sites in the southeastern corner of Wayne County in north central New York State (figure 1). According to a recent map of Wisconsin glaciation published by the Geological Society of America (Flint et al, 1959), the maximum advance of the most recent ice expansion in New York State reached a point about 10 miles south of the stations sampled in this study. Impounding, following the retreat of this expansion, resulted in the formation of an extensive glacial lake (Lake Iroquois?). The GSA map shows the southern shore of this lake to be several miles north of the area presently under consideration. The flora and very interesting history of this region are given in a comprehensive work by Wiegand and Eames (1925). Information regarding the physiographic history of the area is given by Fairchild (1934).

Crusoe Lake (Site I). Crusoe Lake is the most westerly of the three sample areas (figure 1). It is a very shallow lake in which the water depth varies from 1.0 to 0.5 meters in winter and spring to none at all in late summer. It is about 1.5 miles northwest of the town of Savannah lying in a depression mostly below the 380-foot contour line and completely surrounded by swampy lowland. The lake is oriented in a north-south direction, with a length of about 1 mile and a width of about one-fifth of a mile. On the east and west margins of the lake the belt of lowland is rather narrow, but north and south it extends several miles converging with the Montezuma Marsh to the south. A small stream, Butler Creek, flows into Crusoe Lake from the north and the lake is drained by Crusoe Creek, which flows into the Seneca River. The Seneca River is a meandering drainage which swings abruptly to the east at the study area, eventually joining the Oswego River to flow into Lake Ontario.

Bordering the lake for a variable distance averaging about 200 yards, is an elm-ash-maple swamp forest. Along the margin of the water the most conspicuous genera are *Typha*, *Decodon*, and *Lythrum*. A list of vascular plants along the lake margin and in the nearby woods (swamp forest), identified in the field by Stanley J. Smith, Curator of Botany, New York State Museum, is given below. Those species found in abundance are indicated by an asterisk.

Acer rubrum L. subsp. *rubrum**

Arisaema triphyllum (L.) Schott subsp. *triphyllum*

Bidens sp. (cf. *B. frondosa* L.)

Boehmeria cylindrica (L.) Sw. var. *cylindrica*

Carex crinita Lam.

Carex cristatella Britton

Carex lupulina Muhl.
Carex pseudocyperus L.
Carex retrorsa Schwein.
Carex stipata Muhl. var. *stipata*
Cicuta bulbifera L.
Cinna arundinacea L.
Circaea quadrisulcata (Maxim) Franch. & Sav. var. *canadensis*
(L.) Hara
Cuscuta gronovii Willd.
Decodon verticillatus (L.) Ell.*
Dryopteris spinulosa (O. F. Müll.) Watt subsp. *spinulosa*
Eleocharis acicularis (L.) R. & S.
Elymus virginicus L. var. *virginicus*
Fraxinus americana L. subsp. *americana*
Fraxinus pennsylvanica Marsh. subsp. *pennsylvanica*, including var.
lanceolata (Borkh.) Sarg.*
Fraxinus nigra Marsh.
Glyceria striata (Lam.) Hitchc. subsp. *striata*
Ilex verticillata (L.) Gray
Iris versicolor L.
Lemna minor L.
Lindera benzoin (L.) Blume var. *benzoin*
Ludwigia palustris (L.) Ell. var. *americana* (DC.) Fern. & Griseb.
Lythrum salicaria L.
Matteuccia struthiopteris (L.) Todaro var. *pennsylvanica* (Willd.)
Morton
Onoclea sensibilis L.*
Osmunda cinnamomea L.
Osmunda regalis L. var. *spectabilis* (Willd.) Gray*
Parthenocissus quinquefolia (L.) Planch.
Peltandra virginica (L.) Kunth
Penthorum sedoides L.
Polygonum coccineum Muhl.
Rhus toxicodendron L. subsp. *radicans* (L.) Clausen*
Ribes americanum Mill.
Rubus pubescens Raf.
Rumex verticillatus L.
Sagittaria latifolia Willd.
Saururus cernuus L.*
Smilacina stellata (L.) Desf.
Symplocarpus foetidus (L.) Nutt.
Thalictrum pubescens Pursh*
Thelypteris palustris Schott var. *pubescens* (Lawson) Fern.*

Ulmus americana L.*

Viburnum dentatum L. var. *lucidum* Ait.

Viburnum lentago L.

Samples from Crusoe Lake were taken at the south end of the lake at about one-third of the distance between the south and north ends and approximately in the middle, measured from east to west.

Savannah (Site II). The Savannah site is about four-fifths of a mile east of Crusoe Lake and 1.5 miles north of the town of Savannah on N.Y. Route 414 (figure 1). The samples were taken in a depression bordering the stream, near a bridge where the road crosses Crusoe Creek. Nearby, to the north and south of the creek, above the 380-foot contour level, are cultivated fields. The wooded areas in the vicinity are similar to those around Crusoe Lake.

Bluff Point (Site III). Bluff Point is slightly south and about 2.2 miles east of the town of Savannah (figure 1). It is almost opposite the place where Crusoe Creek joins the Seneca River. An island of hard ground rising above the 380-foot contour line, Bluff Point is completely surrounded by low marshy ground. At the time samples were taken, this marsh was covered with extensive stands of cattail (*Typha angustifolia* and *T. latifolia*) and reed canary grass (*Phalaris arundinacea*).

Samples were taken about one-fourth of the way between Bluff Point and Hickory Hill, near a man-made channel linking the Barge Canal with the channel of the Seneca River. On either side of the channel near the sample area is a stand of cattail that is about 20 yards wide. Between the *Typha* border and the hard ground of Bluff Point is a very dense zone of reed canary grass. This almost pure stand of grass extends to within 10 or 15 yards of the *Typha* stand; then it begins to thin out, and a number of other species are found in a zone between the *Phalaris* and the *Typha*. It was in this transition zone that samples were taken for pollen analysis.

METHODS

Field Technique. A Hiller peat sampler was used to collect samples at intervals of 10 centimeters. At Crusoe Lake, the sampling was done through about 0.5 meters of water from a floating platform constructed by lashing two boats together with two-by-fours. This gave the structure stability and formed a satisfactory platform from which to work. Samples were taken through the space between the

boats in alternate holes about 1 meter apart. The alternate hole type of sampling was used at the Bluff Point and Savannah sites also.

In removing the peat from the chamber of the sampler, the surface peat was scraped away and a few grams for analysis taken from inside the core. Each sample was wrapped in aluminum foil and placed in a pint polyethylene bag with a label inside. Later, in the laboratory, these samples were transferred to labeled glass vials and stored in 30 percent alcohol.

The Hiller sampler used for this study takes a core 50 cm. long and about 2.5 cm. in diameter. After the five samples for analysis had been removed from each 50 cm. core, the remainder of the core was placed in a polyethylene bag to be inspected for seeds, shells, etc. The entire column extended to a depth of 11.7 meters at Crusoe Lake, 3.47 meters at Savannah, and 7.2 meters at Bluff Point.

Two cores were taken from the Savannah station. Site IIA provided a core to a depth of 2.63 meters where boulders were encountered. The sampler was moved downstream about 5 meters and a core (site IIB) was taken from 2.5 to 3.47 meters. At this point boulders were again encountered, after passing through a layer of blue clay.

Laboratory Technique. Those samples with a high mineral content were placed in HF for 24 hours, followed by heating to the boiling point. After rinsing in HCl and distilled water, the sediments were boiled in 5 percent KOH and acetolyzed. The residue was mounted in glycerin jelly prestained with either crystal violet or basic fuchsin. The sediments which did not contain appreciable amounts of mineral matter were treated similarly with the omission of HF.

A minimum of 150 tree pollens were counted, except where a scarcity of pollen on the slide made this impossible. The count was made using a binocular microscope with a calibrated mechanical stage. Most of the counts were made at 440X with occasional shifts to oil immersion, and the number of sweeps necessary for the minimum count was recorded. Later, the same number of sweeps was made using a similar type of microscope and only the nonarboreal pollen identified and recorded. Percentages presented here are based on the total pollen count, excluding aquatics and spores of ferns and mosses, except at site III where high grass counts made this method impractical.

In the zones of high *Pinus* occurrence in the profile, as the pine was identified its size was recorded. Where possible, the grains were measured from wing base to wing base and recorded in two categories: those under 50 microns and those larger.

ANALYSES AND STRATIGRAPHY

Crusoe Lake (Site I). The Crusoe Lake profile (figure 2) begins at 11.8 meters and extends with one break to 0.5 meters. The 0.5 meter level records the depth of the water at the time the samples were taken. There can be little doubt that the profile represents most of the postglacial record and it is believed to have late-glacial implications also. The profile begins with a very strong representation of pine and a smaller amount of spruce, with low maxima represented in the oak and birch curves. *Pinus* drops away rapidly above 11.7 meters and *Picea* advances to a maximum at 11.4 meters where *Pinus* is at a minimum. Accompanying this, the *Quercus* and *Betula* percentages show decreases.

From 11.4 to 11.0 meters, *Picea* drops to a minimum, while *Pinus* is rising to a second maximum. At this point, *Betula* shows a sharp advance, but *Quercus* continues at a low level.

Between 11.0 and 8.4 meters, *Picea* and *Pinus* undergo a series of complementary fluctuations, with *Picea* reaching a second maximum and *Pinus* a second minimum. *Betula* continues sporadically, but *Quercus* maintains a higher level than before with more constancy until it drops to a very low level as the *Pinus* minimum is approached. In the upper two-thirds of this zone, *Larix*, *Tsuga*, and *Abies* make their appearance.

Above 8.4 meters, *Pinus* rises to a third prominent maximum, subsequent to a very low *Abies* maximum while *Picea* is declining. Shortly above this *Pinus* peak, there are noticeably sharp increases in *Abies*, *Tsuga*, *Fagus*, and *Quercus*.

Tsuga continues to rise and reaches a peak at 5.6 meters that is maintained, with some fluctuation, to 5.1 meters. Between these points, *Fagus* rises constantly, and *Quercus* falls to a minimum. *Pinus* drops to a relatively low percentage while the broad-leaved genera are well represented between these levels.

At 5.1 meters, *Tsuga* begins to fall away suddenly to a minimum at 4.4 meters, then rises to a medium percentage and descends to a second minimum at 1.4 meters. Corresponding with these two minima, *Fagus* and *Quercus* rise to maxima. In both cases, the maximum is separated by a depression that agrees with the intermediate rise of *Tsuga*. *Pinus* maintains a steady low level and rises to a low peak coincident with the second *Tsuga* minimum. The *Carya* curve shows a maximal rise corresponding with the end of the hemlock intermediate advance.

Above 1.4 meters, the *Tsuga* curve rises to a second major peak near the surface. *Fagus* drops very noticeably in the surface layers,

while *Quercus* declines only slightly from its maximum at the second hemlock depression. *Ulmus* and *Betula* are strongly represented in the surface layers.

Stratigraphically, the Crusoe Lake sediments are composed mostly of marly gyttja in the upper layers. From 0.5 to 1.3 meters, the sediments include an abundance of shells. Below this level, from 1.4 to about 4.8 meters, shells are much fewer. They become abundant again between 4.8 and 5.8 meters. The sediments at 7.7 meters consist of fine sandy clay which grades into blue clay at 8.7 meters. Blue to gray clay persists from this level to the bottom, where black streaks appear in the clay between 11.3 and 11.8 meters. Below this level, the sampler became so fouled that it refused to open.

Savannah (Site II). The Savannah profile (figure 4) is a composite formed from two different cores about 5 meters apart. Site IIA apparently takes up where site IIB leaves off, with very little overlapping.

The profile begins at the bottom of IIB with a strong component of pine and spruce accompanied by smaller quantities of oak, birch, and fir. Between 3.47 and 2.80 meters *Picea* drops to a very low level while *Pinus*, *Abies*, *Betula*, and *Quercus* undergo significant increases. *Abies* increases to a maximum as *Picea* drops and *Pinus* increases to a very high constant level.

By the time the *Abies* maximum begins to drop at 2.6 meters, *Quercus* and *Betula* have become firmly established and other broad-leaved genera are represented.

The IIA profile begins at this point, and the first noticeable change is an important rise in *Pinus* to a prominent maximum at 1.8 meters. *Pinus* starts to decline above 1.8 meters and *Quercus* rises to an important maximum. *Tsuga* starts a rise at the *Pinus* peak which culminates in a maximum at 0.8 meters and continues to the surface. The oak decreases as hemlock rises, and in the surface levels oak is moderately represented. *Pinus* is strongly represented in the surface levels of the profile, along with *Acer* and *Tilia*.

Below 3.37 meters, site II stratigraphy consists of clay overlying boulders at 3.47 meters. Above the former level is marl, which extends to the 1.2 meter level. At 1.2 meters marl gives way to light brown organic sediment, which grades into dark brown peat at 0.7 meters. From 0.4 meters to the surface the core consists of black muck.

Bluff Point (Site III). The Bluff Point profile (figure 5) begins at 7.2 meters with what appears to be a pine-hemlock forest in which the broad-leaved genera, especially oak and beech, are well estab-

lished. There is a sudden change in hemlock frequency at 6.0 meters as it drops to a low level with pine, beech, and oak showing increases. This is the beginning of a long interval of low *Tsuga* percentages which ends at 1.1 meters. Above this level, *Tsuga* again rises to a position of prominence in the profile. From the 6.0 to the 1.2 meter level, *Pinus* and *Quercus* are the most important components of the profile, with *Fagus*, *Carya*, and *Ulmus* strongly represented. Beginning at 0.7 meters *Pinus* increases to a position of importance at the surface, while *Fagus*, *Carya*, *Ulmus*, and most of the other broad-leaved genera show decreases. *Quercus*, *Tsuga*, and *Pinus* are very prominent in the surface layer.

The first 0.3 meters at Bluff Point consist of very soft muck. Below this level varying shades of fine brown peat persist to 6.4 meters. At this level, marly clay begins and extends to 7.2 meters, interspersed with three distinct layers of shells between 6.9 and 7.2 meters. Below this, the sediments were so firm that further penetration by the sampler was impossible.

DISCUSSION

Crusoe Lake is the most complete profile presented here, and two interpretations of its lower $1\frac{1}{2}$ meters are possible. The profile may represent only postglacial time or the bottom levels may reflect late-glacial climatic oscillations. If the former interpretation is accepted, the diagram shows an unusually long spruce-pine zone. This does not necessarily mean a proportionately long interval of time but may be the result of rapid accumulation of sediments.

Postglacial Interpretation. There are two recognizable vegetative fluctuations below the 9.7 meter level. Between 11.7 and 11.3 meters there is a *Picea* maximum accompanied by minima in *Pinus* and nonarbooreal pollen. This has been designated zone L2 (figures 2 and 3), and it may represent the original invasion by vegetation following the retreat of the Valdres ice. Between 11.2 and 10.2 meters, there are a series of *Pinus* and NAP maxima and a *Picea* minimum which have been designated zone L3. The high incidence of non-arbooreal pollen (figure 3) suggests an open vegetation. Zone L3 may reflect a cooling trend brought on by an oscillation in the melt-back of the ice front and characterized by a more or less open vegetation with spruce and pine growing on favorable sites. For reasons which will be discussed later, the pine curve may not be reliable in this zone. The interpretation of the profile from the 10.1 meter level to the surface is the same whether one considers the bottom levels postglacial or late-glacial.

Late-Glacial Interpretation. If a late-glacial phase is assumed, zones L2 and L3 can be correlated with late-glacial zones that have been identified for other parts of eastern North America. Most of the identifiable herbaceous pollen in the lower 1½ meters of the profile are *Gramineae* and *Cyperaceae* (figure 3). Deevey (1951) used these as indicators of open vegetation in his original identification of late-glacial pollen zones in Maine. Deevey, however, found much higher percentages of NAP than were identified in the present study. More recent papers by Andersen (1954), Martin (1958), Livingstone and Livingstone (1958), Ogden (1959), and Frey (1959) indicate that smaller percentages of herbaceous pollen may have late-glacial significance. It should be recognized, however, that AP/NAP ratios without the identification of specific open-vegetation indicators are to be accepted with great reservations.

Three possible late-glacial zones have been tentatively identified at Crusoe Lake. The 11.8 and 11.7 meter levels show herbaceous and pine pollen increasing, with spruce declining. This may represent the retreat of a pre-Valders ice front. The *Picea* peak with the *Pinus* and NAP minima in zone L2 can be interpreted as indicative of a warming trend which allowed spruce to become established in the area. The spruce curve depression in zone L3 accompanied by high percentages of NAP may be taken to represent a return to colder conditions.

The behavior of pine in these zones is not easy to explain. Pollen size-frequency data show that it is all large-grained. This suggests *Pinus strobus* or *P. resinosa*. It is hard to imagine either of these species growing under park-tundra conditions. There are several possibilities that will explain the presence of large pine pollen in this part of the profile. In the first place, it may be the result of expansion during the KOH and acetolysis treatments. Livingstone and Livingstone (1958) report similar difficulties. Secondly, it may represent redeposition from older deposits. Andersen (1954), Martin (1958), Livingstone and Livingstone (1958); Davis (1961), and others have reported instances of this phenomenon in late-glacial deposits in North America. Also, long distance transport by wind of the pollen of *P. strobus* or *P. resinosa* could explain their presence in Crusoe Lake deposits. Any combination of these may have occurred, so that little significance can be attached to the pine curve in these zones.

A hesitant correlation with Deevey's (1951) L zones in Maine is suggested here. His L1 and L3 cold zones, characterized by high NAP and low spruce, compare well with zones L1 and L3 respectively at Crusoe Lake. Deevey's "Aroostook Oscillation" or L2 with a

lower herbaceous count and higher percentages of *Picea* and *Betula* in Maine correlates with zone L2 at site I.

Deevey (1951) suggested that all of his L zones in Maine represent tundra, the arboreal pollen being the result of long distance transport by wind. Livingstone and Livingstone (1958) have suggested that their L1 and L3 zones may have been characterized by "scattered patches of trees." The NAP percentages at Crusoe Lake, though not so high as in Maine and Nova Scotia, favor an open vegetation during L1 and L3 times. These zones are similar to one another in showing high NAP and *Pinus* with low *Picea*. Whether or not they represent actual climatic and vegetational changes, the pine and spruce oscillations certainly appear to be zone markers in the profile. The L1 and L3 zones at Crusoe Lake differ in the higher proportion of *Betula* and herbaceous pollen in L3 than in L1. L2 is characterized by a maximum in *Picea* and minima in *Pinus*, *Cyperaceae*, *Ambrosia*, and other composites. This is evidence for a less open vegetation during L2 times with a higher incidence of spruce. If the L zones in the Crusoe Lake profile do represent late-glacial time, it is not probable that the vegetation in the surrounding area was of the type that Polunin (1961, p. 382) describes as high, low, or middle arctic tundra. It may have more closely resembled the "taiga" he describes (p. 346).

The occurrence of up to 8 percent of *Quercus* in the L zones of the diagram is anomalous. No species of oak in North America today has an arctic distribution. Pollen of this genus, however, has been identified repeatedly in late-glacial pollen zones. Andersen (1954), Martin (1958), and Livingstone and Livingstone (1958) have concluded that in their samples this is the result of redeposition. Deevey (1951) is of the opinion that it was windblown from a great distance. Davis (1958) contends that the oak pollen in these zones of her diagram came from plants growing in the vicinity. The area of her study was probably 200 or more miles south of the Valders maximum advance, so it seems likely that she has given a valid explanation. Our present interpretation places the Crusoe Lake site much closer to the ice front, and we believe that oak in the vicinity does not seem likely. The lack of organic matter in the sediments of the L zones at Crusoe Lake tends to support this hypothesis. Small numbers of *Acer*, *Fraxinus*, and *Ulmus* were identified with *Quercus* in these zones. As Fries (1962) has suggested, a climate warm enough for these genera to grow in the vicinity should have produced a greater quantity of micro- and macro-organisms in the lake than there is evidence of in the sediments. There is the possibility that the pollen of these temperate deciduous trees was deposited as the

result of long distance transport by wind. However, the probable anticyclonic circulation of cold air away from the ice front (Dillon, 1956) offers a hazard to this hypothesis. These genera disappeared from the profile shortly after the postulated invasion of postglacial spruce. This could represent merely a change in relative abundance, or the pollen may be rebedded and its drop marks the end of solifluction and slope wash following the retreat of the Valdres ice front.

It is possible that during the deposition of the deepest sediments at Crusoe Lake the whole area was covered by an extensive body of water, bordered on the north by the southern margin of the glacier. Many of the herbaceous indicators of tundra are entomophilous and those which are not are often low growing and thus less subject to pollen transport by wind. These considerations and the possible outflowing of cold air from the glacier may explain the low absolute pollen frequency and the low NAP percentages in the bottom levels at Crusoe Lake.

It should not be overlooked that the bottom sediments (at Crusoe Lake) could have been the result of rafting from the nearby ice front. This would explain some of the erratic fluctuations in the pollen curves at these levels. At this writing, there is no clear evidence that rafting did occur. In the light of such evidence, the profile for the lower four meters would have to be reexamined with much less confidence in the pollen zones identified here.

In the absence of radiocarbon dates, it is impossible to decide with certainty whether the bottom $1\frac{1}{2}$ meters at site I represent late-glacial or early postglacial time. If this represents late-glacial time, it becomes apparent that the Valdres readvance of the Wisconsin ice did not cover the area included in this study. However, the accumulation of more data is necessary in order to settle this important question conclusively.

Above the zone identified as L3, the nonarborescent pollen drops to around 10 percent, accompanied by an increase in spruce and a decrease in pine. Following Deevey's (1951) interpretation, this is accepted as marking the development of postglacial closed spruce forests in the area.

Zone A. The postglacial spruce zone has been widely recognized in eastern North American profiles and given the designation A by Deevey (1939). This usage will be followed in the present paper. A1 at Crusoe Lake is characterized by the appearance of *Larix*, with a minor increase in *Betula* and relatively high values for *Gramineae* and *Cyperaceae*. The continuing presence of possibly rebedded pollen of deciduous species, especially oak, may indicate that a considerable amount of slope wash resulting from an incomplete cover of vegeta-

tion was still going on. A2 shows a maximum of 66 percent for *Picea* and a corresponding drop in *Pinus*. The herbaceous pollen falls to about 10 percent and oak disappears completely from the diagram. This may signify a complete closure of the vegetational cover and a decrease in erosion and redeposition. The presence of *Abies* and *Tsuga* in A2 is associated with a probable increase in moisture and temperature during this time. The A3 zone is very weakly represented at Crusoe Lake but more strongly at site IIB. At both stations, it is characterized by maxima in the *Betula* and *Abies* curves.

Zone B. The pine zone is very doubtfully indicated at site I but well shown at IIA. At site IIA, it is accompanied by a sharp drop in *Betula* and a minor maximum in *Quercus*. The sediment column from site I is interrupted at this point by a water pocket which extends through 1.5 meters to the 5.8 meter level. This probably accounts for the very short pine period and may represent an unconformity. If this is the case, the hiatus appears to be of short duration as the profile recommences at 5.9 meters in early C1 time.

Above the pine zone at site IIA, the diagram is untrustworthy. The rise of *Tsuga* may indicate the beginning of C1 time or there may be an unconformity between 1.8 and 1.0 meters, with the top meter representing C3 time. The increase in *Picea* is evidence for the latter, while the increase in *Quercus* at the 1.6 meter level supports the former. If the C1 zone is present, the profile is truncated at the top with C2 and C3 missing. If there is an unconformity, zones C1 and C2 are missing. Evidence from an archeological trench, which will be discussed later, lends a strong argument for the latter hypothesis.

Samples of the water between 7.6 and 5.8 meters at site I were brought up in the Hiller sampler and stored in plastic bags. The water from the middle of the pocket contained no pollen but countable numbers were found in the upper and lower samples. This is probably the result of contamination from the sediments that enclose the pocket above and below. The increase in *Gramineae* and *Cyperaceae* below, and of *Ambrosia* above, however, cannot be explained so easily. Comparison with the surface sample suggests a solution to the problem, as the surface level shows high percentages of the same pollen types. The water pocket may be contaminated by seepage from the open water in the lake.

Zone C. The C zones are present in both the Bluff Point (site III) and the Crusoe Lake (site I) profiles. The two diagrams correlate very well in showing C1 and C3 characterized by pronounced *Tsuga* maxima and C2 by a *Tsuga* depression. These oscillations

have been previously established in New York State by Deevey (1943), Sheldon (1952), Cox (1959), and Durkee (1960).

C1 at both stations is emphasized by a hemlock maximum with rising beech and strong representations of oak and other broad-leaved genera. The pine curve at Bluff Point is evidently the result of a local disturbance. The normal pine curve for this section of the diagram in central New York State is probably more accurately described by the Crusoe Lake pine curve.

The C2 zone at site I is complicated by a minor readvance of *Tsuga*, set off by two *Tsuga* minima. Pollen spectra presented by Cox (1959), Durkee (1960), and Brown (personal communication) point to the possibility that this is a regional oscillation rather than a local disturbance. There is evidence at Crusoe Lake for three C2 subzones, tentatively identified as C2a, C2b, and C2c.

C2a is recognized by a hemlock minimum with a beech maximum. Smaller advances in *Quercus* and *Nyssa* are present, coincident with a peak in *Cyperaceae*. *Tsuga* readvances in C2b as *Carya* attains a maximum and *Fagus* a minimum. In C2c, *Tsuga* again falls to a minimum, while *Fagus* is rising to a lower peak and *Quercus* to a higher peak than in C2a. Apparently C2 time was characterized by two periods of relative dryness separated by an interval when there was more available moisture. The high *Fagus* percentages in C2a and the strong occurrence of *Quercus* in C2c suggest drier climatic conditions in the latter than in the former. The rise in pine and sedge pollen in C2c is further evidence for this interpretation. The *Carya* peak that occurs in C2b comes at the end of the period, and *Carya* continues at relatively high percentages until early C3 time. Cox (1959) has given reasons for accepting the hypothesis that the vegetative fluctuations characterizing C2 time in central New York were the result of temperature changes only. The data presented here do not justify a more elaborate interpretation.

These subzones are less pronounced in the Bluff Point histogram for possibly two reasons: (1) the disturbance created by the pine pollen curve and (2) the elongated profile representing C2 time. A rapid accumulation of sediments is undoubtedly responsible for the latter. According to Deevey and Flint (1957), C2 time lasted for about 3,000 years. During this time, 3.8 meters of sediments accumulated at site I and 4.8 meters at site III. The sediment columns for C1 and C3 are of approximately equal lengths at the two stations.

Hemlock rises to a second major peak marking the end of C2 and the beginning of C3 at both Bluff Point and Crusoe Lake. *Quercus* continues at a high level, but *Fagus* falls off sharply in the surface levels. *Picea* reappears at site III. In most of the pollen profiles

that have been constructed for New York State, the *Tsuga* maximum in C1 is greater than in C3. *Picea* is virtually absent from C1 but is characteristic of C3. If the C3 spruce is accepted as indicative of climatic change, the higher *Tsuga* count and the absence of *Picea* in C1 is strong evidence for a warmer and more moist climate than in C3.

Some components of the NAP curve at site III are of considerable interest. The most pronounced feature is the sudden jump of grass from zero in the basal clay to conspicuous values which are maintained to the top. Within this part of the curve, grass represents as much as 57 percent of the total pollen. As the grass pollen was identified it was measured and its size recorded (figure 6). Most of it in the upper 1.8 meters compared favorably in size with the pollen of *Phalaris arundinacea*, which is presently abundant in the area. If it is assumed that the grass pollen in the upper 1.8 meters of sediment is *Phalaris*, it seems that, except for changes in water depth, conditions in the vicinity of site III may have been much the same since late C2 time with spring flooding and marshy summer savannahs.

Carbon 14 Dates. In the summer of 1959, after the pollen diagram had been constructed, samples for radiocarbon dating were taken from Crusoe Lake using the multiple-shot technique with the Hiller sampler. Pollen counts were made above and below the levels to be dated to confirm their place in the profile. The depths chosen were the beginning and the end of the C2 period at 5.0 and 1.3 meters respectively, as indicated by the pollen curve. The former was dated at 6850 ± 150 (I220) and the latter at 3200 ± 100 (I219) years before the present. Both of these dates are over a thousand years too old to represent the limits of C2 time suggested by Deevey and Flint (1957). It is not impossible that these dates mark the limits of C2 time in central New York State, but it seems improbable. There is no other evidence to support so great a disagreement with other sections of eastern United States, but to our knowledge there are no other radiocarbon datings of pollen zones from this region of the State. The evidence at this time, however, favors contamination of the dated samples with carbon from an older source. An error of this magnitude could result from the assimilation by living organisms of carbon from older carbonates. Since we have been unable to specifically identify any other source of contamination, this hypothesis for the deviation in the above dates is tentatively accepted here.

Indian Cultures. The location of the area for the present study was chosen in view of the many prehistoric Indian sites in this vicinity as reported by Harold Secor (personal communication). These sites, scattered over a rather wide geographical area, share the common feature of occurring along the 380-foot contour line (figure 1).

Ritchie (1951a) has described the Archaic Lamoka Indian culture in New York State and has given a radiocarbon date for it of about 3500 B.C. This is about the middle of the hypsithermal period of Deevey and Flint (1957) and about the end of the C1 period as it occurred in south-central New England. The above date would probably fall in the upper third of the first hemlock zone in New York State as set forth by Cox (1959). The forests there during this interval probably consisted largely of *Tsuga* and *Fagus*, with *Quercus* occurring on the south-facing slopes and ridges.

The Indian campsites involved in the present study are believed to reflect a more recent culture than the one mentioned above. On November 19, 1959, an archeological test pit was excavated by Ritchie and Secor about 10 feet from the point where the site IIA sediment column was taken. As the pit deepened, samples were collected at and below levels which held evidence for the presence of man. A summary of the notes taken by Ritchie for each of the seven samples is given below:

Sample 1. Depth 8 inches from surface. Crumbling Indian pottery found with this sample.

Sample 2. Depth 9-10 inches. Taken just over layer of deer bones, many broken for marrow extraction. No artifacts found with bone on this level.

Sample 3. Depth 12 inches. Sample taken among deer bones. One rude, stemmed, flint point or knife and one flint and scraper found among bones.

Sample 4. Depth 13 inches. Taken immediately below bone layer. Scattered deer bones still present at this depth, and below to 15 inches from surface.

Sample 5. Depth 15 inches. The random scatter of deer bones disappeared below this depth, as did all other evidence of the presence of man.

Sample 6. Depth 19-20 inches. To this depth the soil appeared black and granular, like woods mould or rotted duff. At this level occurred a thin, compact, lenticular stratum which appeared to us to resemble matted bark or more probably reeds and other marsh vegetation. This sample was taken off the top of this matted layer, directly in contact with it.

Sample 7. Depth 22 inches. At this level a reddish layer, apparently of limonite or bog iron, c. 1 inch thick, was present throughout the excavation, which was now beginning to fill with water.

Below this horizon, to the maximum depth excavated, i.e., 3 feet, the material appeared to be a uniform peat. All of this deposit was below the current water level.

Later, after examining the material in the laboratory, Ritchie writes (personal communication):

The flint point found at the 12 inch level, being a discard of manufacture, has little diagnostic value, as is also the case with the end scraper found at the same depth.

The potsherd from the upper level yields, however, some helpful information, concerning its cultural and temporal provenience. It consists of a body sherd measuring 2 x 3 inches, cord-malleated on the exterior and faintly straited or channeled on the interior. It is grit tempered and sandy in texture, and has a crude "plat" of corded impressions by way of decoration over the corded surface, i.e. a cord-on-cord treatment. It appears to fit into the Vinette 2 ware group (Ritchie and MacNeish, 1949) of the late Middle Woodland period and to be of Point Peninsula 2 cultural provenience (Ritchie, 1951b). Although not yet radiocarbon dated in the area, this culture probably flourished between about A.D. 500-700.

A pollen profile was constructed from these sediments (figure 7), using the same methods which were described earlier. The diagram indicates a clear correlation with the top meter of the site IIA profile. If the Indians who left their traces here, were in fact, more recent than the Archaic Lamoka Indians, the profile leaves little doubt that they were of C3 time.

A large lake extending into the Montezuma Marsh and having the 380-foot contour as its approximate shoreline is suggested by the many Indian campsites along this line. These camps were probably fishing camps and not contemporaneous. According to Ritchie (personal communication), "a wide range of ages is obvious in these sites—several thousand years!" This lake, then, of which Crusoe Lake is but a remnant, was probably older than C3 time and may have persisted until well after A.D. 500. Figure 7 indicates that during the time the campsite was being used, the surrounding forest consisted of hemlock, pine, and hardwoods, among which oak, maple, and basswood were important.

Summary*

The present study has yielded a vegetational history for the Crusoe Lake area that probably began 10,000 to 12,000 years ago. It is impossible to say whether the Two Creeks interstadial period is represented in the pollen diagram. In any case, the ice front must have been fairly close and the climate severe in this area during the deposition of the bottom $1\frac{1}{2}$ meters. The arboreal vegetation seems to have consisted mainly of spruce and pine with an occasional fir. These probably grew on the more protected sites, with grasses and sedges interspersed with other herbaceous species, partially covering the open spaces.

Apparently, the ice retreated and a closed spruce-pine-fir forest became established before 7500 B.C. The spruce-pine-fir forest seems to have been replaced by one in which pine dominated between 7500 and 6500 B.C. While this forest is not well represented in the Crusoe Lake profile, it has been established in central New York State by other studies. The climatic changes which brought it about were probably an increase in temperature and a decrease in available moisture.

Beginning about 6500 B.C., the first postglacial deciduous forests probably began to establish themselves in central New York State. This was the result of a further increase in temperature, accompanied by an increase in moisture, so that during this period the climate may have been warmer and more moist than it is today. The most important forest trees were probably hemlock in the coves and on the north slopes, with oak occurring on the ridges and south slopes. There is evidence that elm and maple were also well represented in the forest, with beech and hickory beginning to come in toward the end of the period. Archaic Lamoka Indians probably invaded central New York about the end of this interval. The major forest trees during this invasion seem to have been hemlock and oak.

* The dates given in this summary are based on radiocarbon dates given by Deevey and Flint (1957), Deevey (1958), and Ritchie (1957).

Beginning about 3000 B.C. and extending to about 2,000 years ago, was an interval of time during which there was less available moisture than either the period preceding or following it. Based on the pollen record, the most noticeable change in the forests of central New York State was a decrease in the amount of hemlock. Beech probably replaced much of the hemlock on the more moist sites, with oak and hickory abundant on the drier locations. The latter part of this interval may have been drier than the first, as evidenced by the smaller amount of beech and greater proportion of oak. There is evidence for an interval in the middle of this period when available moisture increased.

During the past 2,000 years, there are indications of a decrease in temperature accompanied by an increase in the moisture available to plants. Pollen statistics suggest that the forests during this time were somewhat similar to those which persisted in the interval following the pine period. The earlier interval was probably the warmer of the two and the later one dryer. In both periods, hemlock seems to have been the most abundant forest tree in central New York State. Late Middle Woodland Indians probably flourished in the area around Crusoe Lake during the early part of the most recent climatic interval from A.D. 500 to 700. At this time, a large lake, of which Crusoe Lake is a remnant, may have occupied this basin extending into the Montezuma Marsh. Many Indian campsites, along the 380-foot contour line, suggest fishing camps along the shoreline. These campsites are not contemporaneous but appear to represent a spread in time of several thousand years. This suggests that the lake persisted, at least periodically, from late hypsithermal time to A.D. 700 or later.

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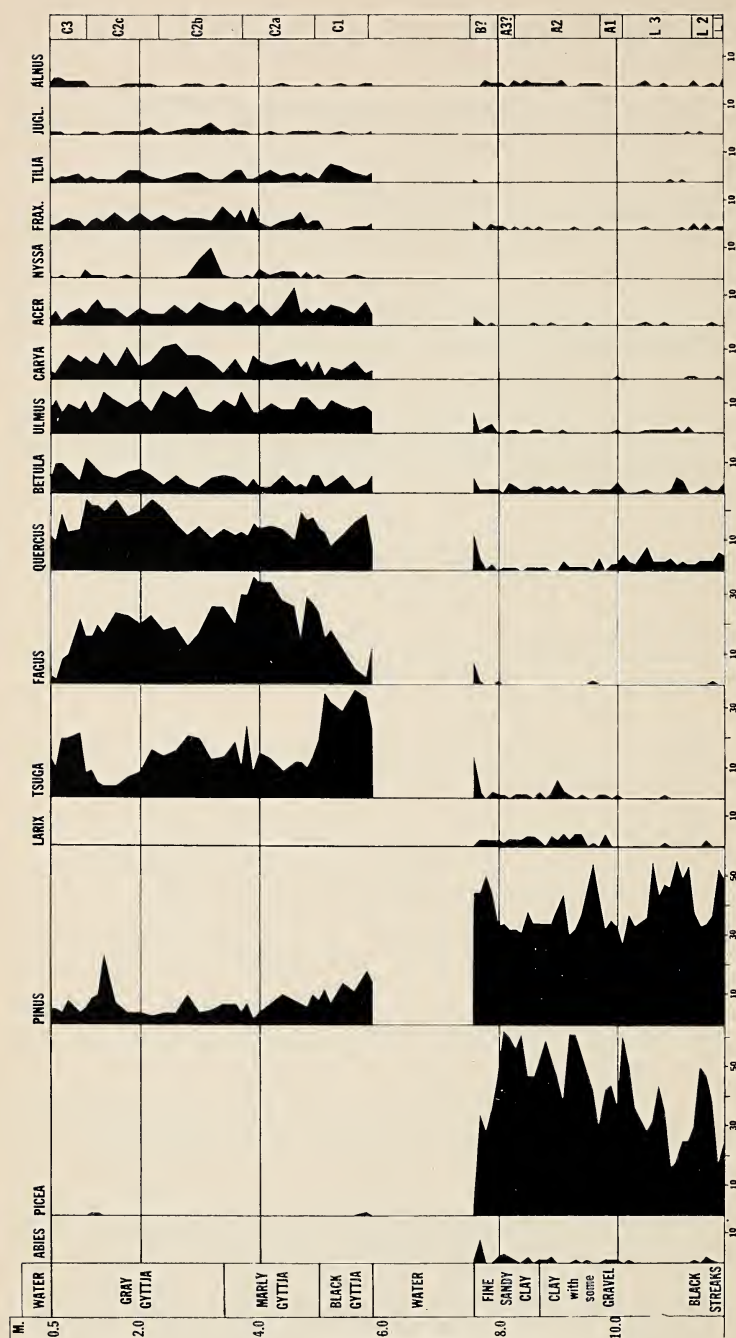


FIGURE 2. Arboreal pollen diagram at site I, Crusoe Lake.



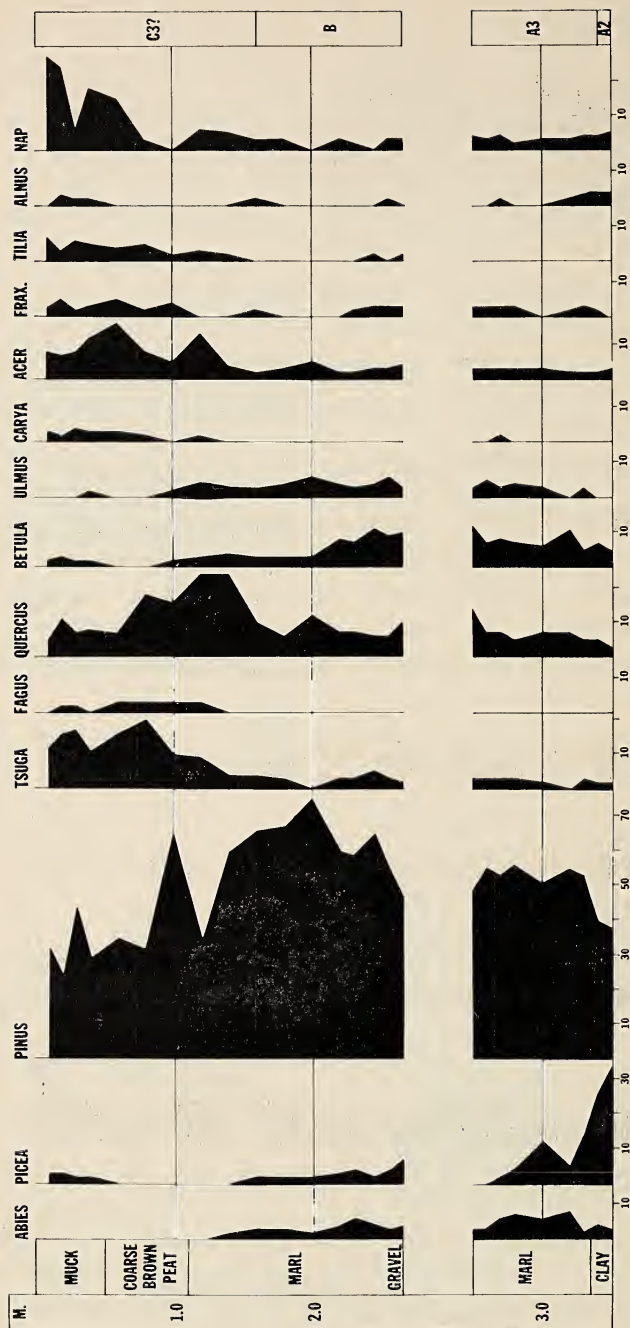
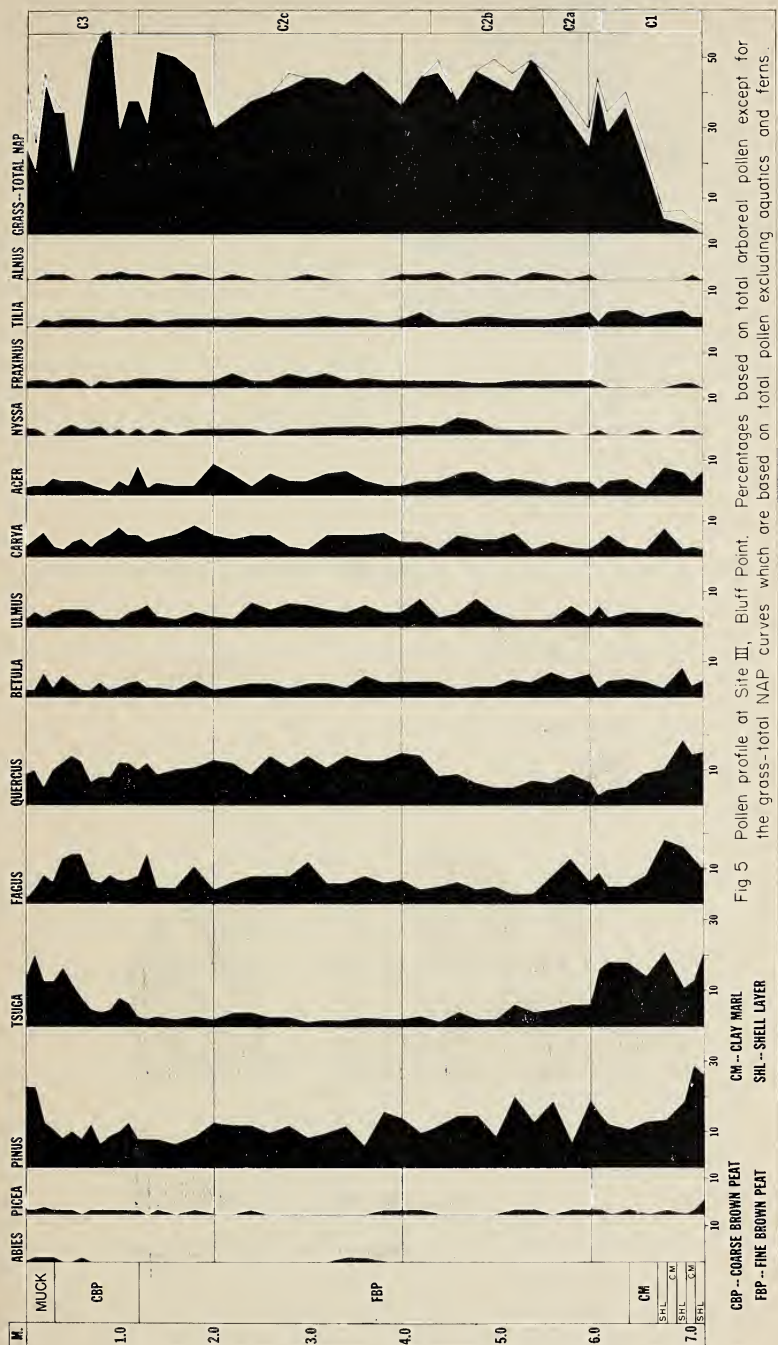


FIGURE 4. Pollen diagram at sites IIA and IIB, Savannah.



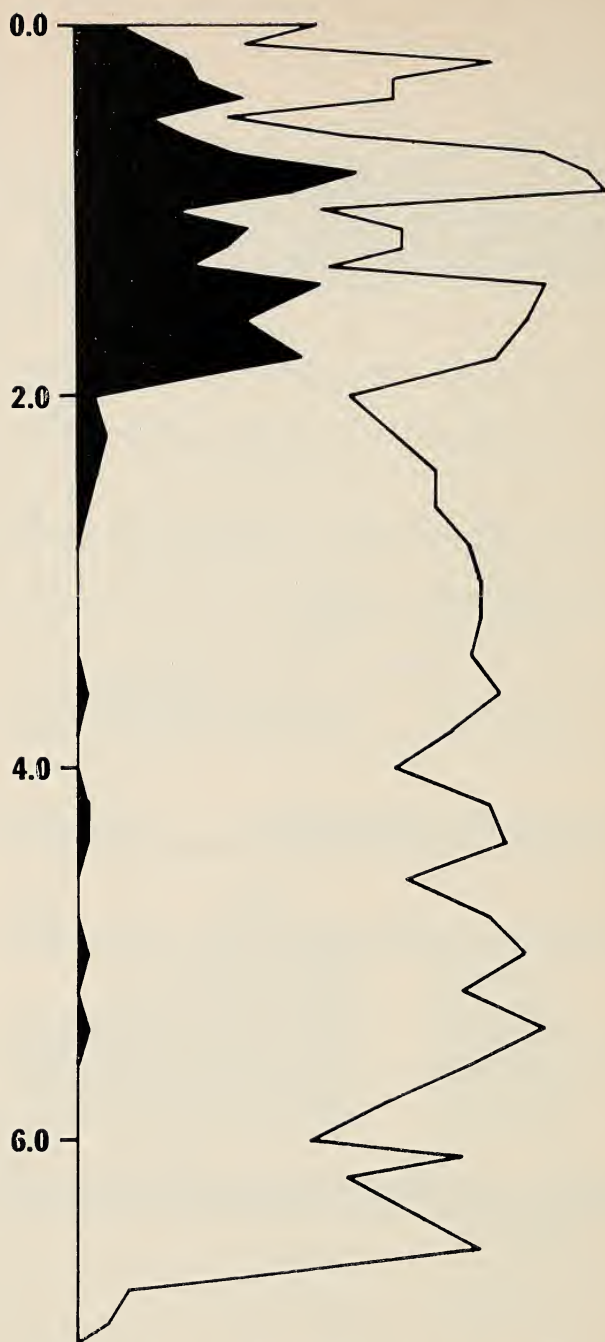


FIGURE 6. Curves showing grass pollen greater than 40 microns and total grass pollen at site III.

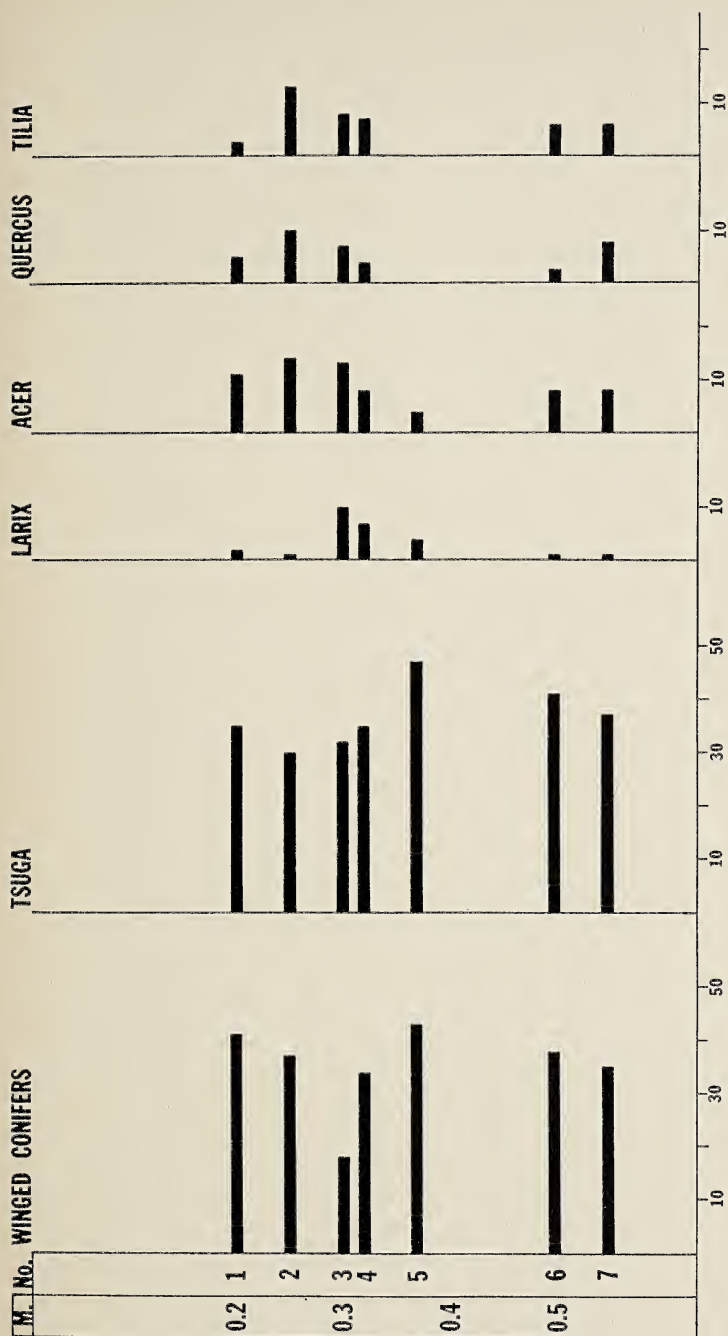


FIGURE 7. Pollen diagram constructed from the seven samples taken from the archeological test pit at site II. Percentages based on total arboreal pollen.

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BULLETIN NUMBER 398

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- 22 Carney, Frank
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GEORGE L. HUBBELL, JR., A.B., LL.B., LL.D., LITT.D., Garden City	1966
CHARLES W. MILLARD, JR., A.B., LL.D., Buffalo	1973
EVERETT J. PENNY, B.C.S., D.C.S., White Plains	1970
CARL H. PFORZHEIMER, JR., A.B., M.B.A., D.C.S., Purchase	1972
EDWARD M. M. WARBURG, B.S., L.H.D., New York	1975
J. CARLTON CORWITH, B.S., Water Mill	1971
JOSEPH W. MCGOVERN, A.B., LL.B., L.H.D., LL.D., New York	1969
ALLEN D. MARSHALL, A.B., LL.D., Scotia	1965
JOSEPH T. KING, A.B., LL.B., Queens	1977
JOSEPH C. INDELICATO, M.D., Brooklyn	1974
MRS. HELEN B. POWER, A.B., LITT.D., Rochester	1976

JAMES E. ALLEN, JR.	President of the University and Commissioner of Education
EWALD B. NYQUIST	Deputy Commissioner of Education
HUGH M. FLICK	Associate Commissioner for Cultural Education
WILLIAM N. FENTON	Assistant Commissioner for State Museum and Science Service
JOHN G. BROUGHTON	State Geologist, State Science Service

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Introduction

This bibliography lists papers relating to the geomorphology, physiography, geology of unconsolidated sediments, and interpretation of Quaternary environments of New York as published in books and periodicals prior to 1963.

This work is a by-product of literature review for current investigations in the glacial geology of western New York. It received limited distribution in preliminary form as an unindexed mimeographed manuscript in 1960. Since that time, the listing has been corrected, expanded, and indexed. It integrates and orients a body of published data referenced in the U.S. Geological Survey *Bibliography of North American Geology* and in principal studies of New York Quaternary geology.

Every bibliography, in its early development at least, reflects the orientation and interests of its compiler, and the present work is no exception. The landscape, for instance, is a principal feature of Quaternary geology. All aspects of New York physiography and geomorphology are included in the bibliography, even though major landforms with pre-Quaternary origins may have undergone little modification during the Pleistocene Epoch. Glaciation and glacial processes as the keys to interpretation of most New York landscapes are given major emphasis in the listings. Detailed stratigraphic studies of Pleistocene deposits are essential for interpretation of Quaternary history and chronology, but lateral variability of terrestrial and particularly glacial deposits has limited the number of significant papers in this field. Paleontologic works are listed only for their environmental and stratigraphic significance, whereas purely taxonomic and morphologic studies are beyond the scope of this bibliography.

This volume includes a note on the history of New York Quaternary investigations, a bibliographic listing of published papers, a geographic index, and a subject index. The listing and the two indexes

are preceded by explanations outlining their form and limitations. All data were tabulated from bibliographic punch cards and are presented in such manner as to facilitate transfer by the user to such cards where repeated use may justify this procedure. Figure 1 illustrates a card suitable for the purpose, with fields defined for author, subject, geographic and chronologic codes.

No claim of completeness is made for this bibliography. Even within limits set for this listing, omitted titles continue to come to hand. Although punch card compilation continues, the listings are being published in present form in order that they may be available for use by specialists and amateurs with an active curiosity about the natural history of their State.

Preparation of this bibliography has been sponsored by the New York State Museum and Science Service as part of its current program of Quaternary investigations. The compiler acknowledges with gratitude the work of William Garrabrant, Science Research Aide, New York State Museum and Science Service, in the patient tracing of numerous references and the help of David Fullerton and Karen Lukas, National Science Foundation grant awardees, in checking of punch card data. Errors reported by recipients of the preliminary mimeographed manuscript have been corrected, and the interest of these persons is appreciated.

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Historical Note on Studies of New York Quaternary Geology¹

by Ernest H. Muller²

and William A. Garrabrant³

New York glacial and topographic features have attracted attention from the days of the first explorers and trappers. The early establishment of the State geological survey under James Hall helped give New York a position of geological leadership that extended into Quaternary research from the days of Diluvial theory through ascendancy of the Glacial theory. The Finger Lake troughs, the drumlin belt, and other features stimulated discussion and original thought on glacial erosion and deposition by active and stagnant ice. The following review of the history of glacial geology in New York indicates the magnitude of the role played by this research in achieving the present status of knowledge of Quaternary problems.

PRIOR TO 1825

Several decades before the scientific foundations of geology had become firmly established, three travelers in the British colonies recorded notes significant for their keen interpretation of geologic features (White, 1953). Lewis Evans, surveyor and geologic observer, first described concordant Appalachian ridges as remnants of a former plain. Traveling with Philadelphia botanist and naturalist John Bartram in 1743 (Bartram, 1751), Evans recognized raised beaches in the vicinity of Onondaga (Syracuse) and hypothesized that uplift resulted from unloading due to partial drainage of the lake basins.

¹ Manuscript submitted for publication April 29, 1963

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This is perhaps the earliest approach to the concept of isostasy (White, 1951). The third of the trio, Peter Kalm, a Swedish traveler and scientist, in 1753 recognized erratic boulders and the obdurate soil called till, but without speculation as to their origin (Benson, 1937).

Remains of extinct Pleistocene mammals early attracted scientific attention, and fossil teeth stimulated speculation as to the possible existence of a former human race of giants. Such was the geologic reference by Cotton Mather in 1712 (Heubusch, 1959). Thomas Jefferson, an eminent paleontological collector as well as statesman and President of the United States, acknowledged receipt of a mastodon specimen from New York.

Prominent topographic features such as the Palisades of the Hudson, the Catskill and Adirondack Mountains, and, most celebrated of all, Niagara Falls received early attention. In 1787, Captain Enys visiting Niagara concluded, on the basis of the abrupt rise of river banks at the Landing (Lewiston) and the observed retreat of the falls within man's memory, that Niagara Falls had once been at the Landing (Brigham, 1914). The earliest estimate of the age of the falls is also one of the largest, for in 1790 William Maclay, using an observed recession rate of 20 feet in 30 years, estimated that 55,440 years had been required for the cutting of Niagara gorge (Kirk, 1932). About 1795, the journal of Timothy Dwight, President of Yale University, contained astute comments on Niagara Falls, the retreat of Glens Falls, and the recession of waterfalls in general. Papers by Darby (1819) and Foot (1822) reflect the continued interest of layman and geologist in the wonder and significance of Niagara Falls.

ASCENDENCE OF THE DILUVIAL THEORY: 1825-1840

Stimulated by expansion of European canal systems, some of the first important geologic and stratigraphic investigations took place in England, France, and Germany during early decades of the 19th century. In New York, too, canal excavation afforded stimulus for observations and conclusions reported in Amos Eaton's "Diluvial Deposits of the State of New York and Elsewhere" (1827).

With the organization of the first geological survey in 1836, New York officially acknowledged the need for information on its geology and natural resources. The State was divided into four districts, each one the responsibility of a geologist and his assistant. Investigations continued into the following decade, studying unconsolidated deposits subordinately along with rocks of the earlier series. When published

in the early forties, reports of the district surveys described drift, erratic boulders, lake clay, and high-level gravels, interpreted by Hall, Emmons, and Mather as diluvium or evidence of drifting icebergs during former submergence of the land. Alone among the district geologists, Lardner Vanuxem in the Third District compared briefly the iceberg and glacial theories and gave preference to the latter, suggesting the term "local ice" for glaciers (Vanuxem, 1842).

An uneasiness foreshadowing the spread of the glacial theory to the United States is expressed in a study by Chester Dewey (1839). Describing the scratched and polished surface of limestone near Rochester, he states, "The surface was not made thus originally. It has been done '*artificially*,' though by nature, by some mighty power. The friction of the water and earth in the Genesee wears somewhat similar surfaces in the same rock, but nothing like the polished surfaces now described."

ACCEPTANCE OF THE GLACIAL THEORY: 1841-1865

By 1841, studies by Bernhardt, Carpentier, and Agassiz in northern Europe had demonstrated that glaciers formerly extended beyond the margins of mountainous areas. The spark of the glacial theory was struck first in North America by Edward Hitchcock in an address in 1841. In New York, the concept of scour by drifting icebergs still dominated the thinking of Mather (1841) and Hall (1843). By 1843, however, Dewey was able to review the problem of the polished and scratched rocks near Rochester in the light of glacial theory, with iceberg rafting as an alternate possibility.

At midcentury, the diluvial and glacial theories were in equal competition for acceptance in explanation of a variety of features and deposits. Both theories had ardent proponents, and both demanded consideration in the minds of unprejudiced observers. Influential European geologists, such as Ramsay and Agassiz, visited north America, seeking evidence in support of these theories. A. C. Ramsay, in the Catskills, "ascending the mountains to Mountain House . . . observed that their flanks are marked by frequent grooves and glacial scratches, running not downhill as they would do if they had been produced by glaciers, but north-south, horizontally along the slopes in a manner that might have been produced by bergs grating along the coast, during submergence. These striations were observed to reach the height of 2,850 feet above the sea. . . . During the greatest amount of submergence of the country, the glacial sea in the valley of the Hud-

son must have been between 3,000 and 4,000 feet deep and it is probable that even the highest tops of the Catskills lay below water" (1858). Although he recognized the extensiveness of glacial drift and spoke of it as transported by ice for several hundred miles, he ascribed the majority of features observed in New York to drifting icebergs rather than glacial flow.

In 1864, Louis Agassiz, writing about "The Ice Period in America," cited the drift in New York and the polished limestones of western New York as unequivocal evidence of continental glaciation. This paper by Agassiz brings to a close the interval which Fairchild (1898) called the period of "gradual acceptance of the glacial theory in America."

The contest between Diluvialist and Glacialist held no monopoly on scientific attention. An impressive group of eminent geologists had, by 1865, made the pilgrimage to Niagara Falls and returned to interpret the geologic significance and the age of the gorge and falls. Among the company were Featherstonhaugh (1831, 1845), Fairholme (1834), Rogers (1835), Hall (1842, 1857), Bakewell (1830, 1847, 1857), Desor (1853, 1854), Gibbes (1857*a*, 1857*b*), and Marcou (1865). Raised beaches of former lakes were traced and described by Whittlesey (1850) in the Erie Basin, and by Desor (1850*b*) in the Ontario Basin. Vertebrate fossil sites were described (Hall, 1846; Brevoort, 1859). Evidence of submergence of the Atlantic Coast was cited by E. H. Cook (1857*a*, 1857*b*).

ASCENDENCE OF THE GLACIAL THEORY: 1866-1890

Once the verity of a former continental glaciation in New York had been established, the debate shifted to the question of the effectiveness of glacial scour. The debate was opened by E. W. Claypole in 1878 with a paper on the preglacial topography of the Great Lakes in which he maintained that the basins are of preglacial origin, modified only superficially by glaciation. In 1882 he reiterated his position more explicitly, citing the thinness of the till sheet south of the lake basins as an argument against intensive glacial scour of the basins. This view was supported by Spencer (1881) but opposed by Newberry (1882) and Gilbert (1885), and the debate between the "gougers" and the "sandpaperers" continued into succeeding decades.

In southeastern New York, a small group of geologists published a significant volume of papers dealing with glacial drift and topographic features of the coastal plan. N. L. Britton described glacial potholes,

plant fossils, modified drift, and drift stratigraphy on Staten Island. F. J. H. Merrill published on aspects of the geology of Long Island and the lower Hudson Valley. John Bryson wrote of modified drift features on Long Island and opposed N. S. Shaler in attributing the character of beach material chiefly to glacial rather than marine derivation on the basis of correlation with glacial drainage channels and moraines. Also concerned with the geology of Long Island are papers by Elias Lewis, T. C. B. Lloyd, and James D. Dana, who discussed, among other things, the vertical stability and changes of level of the coast.

Two major regional studies by T. C. Chamberlin authoritatively related glacial features of New York to the regional pattern in the northeastern United States. The first, in 1883, investigating the "Terminal Moraine of the Second Glacial Epoch" locates the limit of Wisconsin glaciation. The second, in 1888, on "Rock-scorings of the Great Ice Invasions," includes 225 observations of glacial striae in New York as evidence of the directions of glacier flow.

THE GOLDEN AGE IN NEW YORK QUATERNARY RESEARCH: 1891-1920

The final decade of the 19th century marks the beginning of a particularly productive period in discussion of New York Quaternary problems. This was a time of numerous contributions by a large number of glacialists, and New York was a focal area of attention. Of the 41 geologists who contributed five or more papers listed in the accompanying bibliography, 32 were active during the decades from 1891-1920 (table 1). Of the major contributors, Herman L. Fairchild of Rochester was the most prolific, with more than a hundred titles listed over a span of 41 years, covering many subjects but returning repeatedly to discussion of aspects of the proglacial lake sequence and melt-water drainage pattern of parts of the State.

Three other men, all active during this period, contributed 25 or more papers. Although Joseph W. W. Spencer early entered the debate on the origin of the Great Lake basins and developed details of the proglacial lake history, nearly half of his 67 listed publications discuss the age and significance of Niagara Falls. Frank B. Taylor, with 33 papers listed from 1892 to 1939, devoted considerable attention to the interrelationship of moraines and proglacial lake features, developing a basis for correlation of New York history with those of the adjacent States and Canadian provinces. Grove K. Gilbert commenced

his career with an account of the Cohoes mastodon site, joined in discussion of the origin and history of the Great Lakes basins, and described a number of minor features of interest, such as a boulder pavement, superficial dislocations of bedrock, streamline ridges, and a buried hearth in western New York.

During this interval, skirmishing in the continued debate on effectiveness of glacial scour shifted from the Great Lakes basins to the Finger Lakes region of west-central New York. Lincoln (1892), Brigham (1893), Tarr (1894), McGee (1894), and Spencer (1894*g*) utilized rock-basin configuration, U-shaped cross-profile, and gradients of hanging valleys to evaluate the role of ice scour in shaping the Finger Lake troughs. Although initially convinced that glaciation had played a dominant role in the origin of the basins, Tarr's confidence was shaken by discovery of "Some Instances of Moderate Glacial Erosion" (1905*g*). Fairchild, finding "Evidences of slight glacial erosion in western New York" (1904*b*), published on "The ice erosion theory, a fallacy" a year later (1905*a*). By 1906, however, Tarr had recovered confidence, and the essential role of glacial scour in deepening the troughs of Cayuga and Seneca Lakes below sea level subsequently has not been seriously challenged. An historical review by Carney (1909*a*) summarizes the major contributions of New York Quaternary research in development of the ice erosion theory in North America.

Increased availability of topographic maps coupled with growth of State and Federal survey programs resulted in geological mapping in many parts of the State. New York State Museum Bulletins by Alling, Brigham, Carney, Fairchild, Stoller, Woodworth, and others feature discussion of Pleistocene problems in areas where drift cover is thick and glacial features are particularly well-developed. Elsewhere, Quaternary geology was treated routinely by investigating geologists. For some parts of the State, particularly in the Adirondack Mountains, the notes of areal geologists such as Cushing, Kemp, and Miller afford virtually the only available published data even today.

One of the most complete and detailed glacial studies in New York to date is Frank Leverett's (1902) "Glacial Formations and Drainage Features of the Erie and Ohio Basins," a thick monograph which relates glacial and proglacial lake history of western New York to that of adjacent Pennsylvania and Ohio. Folios of the Geologic Atlas of the United States cover the glacial geology of the New York City, Passaic, Watkins Glen-Catatonk, and Niagara areas. Fuller's professional paper summarizing the geology of Long Island (1914) contains a classic analysis of topographic features of fluvio-glacial origin.

Table 1

A chronological listing of scientists with five or more titles
in the Bibliography of New York Quaternary Geology

<i>Name</i>	<i>Dates</i>	<i>Titles</i>	<i>Subject</i>
	<i>of pub.</i>		
Hall, James	1838-1871	9	Survey, 4th Dist., drift, striae, Niagara
Desor, Edouard	1850-1854	5	Former strands, Niagara, marine invertebrates
Lewis, Elias, Jr.	1868-1877	5	Long Island drift, watercourses, stability
Gilbert, Grove K.	1871-1908	25	Niagara, Great Lakes basins, west New York
Lloyd, T. C. B.	1875-1877	5	Long Island watercourses, stability
Claypole, E. W.	1877-1889	6	Great Lakes basins, Niagara
Upham, Warren E.	1879-1920	20	Niagara, isostasy, proglacial lake history
Britton, N. L.	1881-1889	7	Staten Island and Long Island drift features
Julien, A. A.	1881-1910	5	Manhattan and Hudson Valley topography
Spencer, J. W. W.	1881-1921	67	Niagara Falls, Great Lakes origin and history
Davis, William M.	1882-1912	10	Erosion surfaces, Lake Iroquois, mid-Hudson
Bryson, John	1883-1898	17	Long Island drift features
Wright, George F.	1884-1921	10	Niagara Falls, Hudson-Champlain Valley
Merrill, F. J. H.	1886-1902	11	Lower Hudson Valley topography and geology
Hollick, C. A.	1886-1930	12	Staten Island and Long Island, paleobotany
Clarke, John M.	1888-1915	5	Vertebrate fossil localities
Brigham, A. P.	1889-1931	17	Mohawk Valley, Finger Lakes erosion, drift
Dryer, C. R.	1890-1908	6	Finger Lakes, glacier border features
Lincoln, D. F.	1892-1895	5	Finger Lakes, glacier erosion
Leverett, Frank	1892-1939	7	Moraines, former strands, correlation
Taylor, Frank B.	1892-1939	33	Niagara Falls; moraine and strand correlation
Woodworth, Jay B.	1893-1907	5	Pleist. areal geology; Hudson-Champlain Valley
Tarr, Ralph S.	1893-1912	21	Glacial erosion, Finger Lakes, N.Y. physiography
Darton, Nelson H.	1894-1914	5	Helderberg scarp, Catskills, areal geology
Grabau, A. W.	1894-1920	18	Preglacial drainage; post-glacial gorges
Fairchild, H. L.	1894-1935	104	Proglacial lake history; meltwater drainage
Kemp, James F.	1896-1925	12	Adirondack and Hudson Valley physiography
Cushing, H. P.	1901-1925	9	Adirondack and St. Lawrence areal geology
Carney, Frank	1903-1909	10	Finger Lakes, drift stratigraphy, features
Fuller, M. L.	1903-1914	6	Long Island areal geology, Fishers Island
Rich, John L.	1906-1943	11	Catskill glacial geology; ice marginal channels
Cook, John H.	1909-1946	10	Stagnation features in eastern New York
Miller, W. J.	1909-1926	19	Adirondack areal geology; New York geology
Johnson, D. W.	1909-1931	8	Shore features, troughs, cirque glaciers
Chadwick, G. H.	1910-1935	13	Catskill, Adirondack glacial drift and features
Stoller, J. H.	1911-1932	11	Mohawk-Hudson Valley drift features
Engeln, O. D. von	1918-	19	Erosion, deposition; Finger Lakes region
Holmes, C. D.	1927-	12	Drift constitution, central New York
Cole, W. Storrs	1930-	7	Erosion surfaces; gorge-cutting
MacClintock, Paul	1944-	6	Leaching; St. Lawrence and cent. N.Y. moraines
Muller, E. H.	1956-	6	Leaching; west N.Y. moraines and correlation

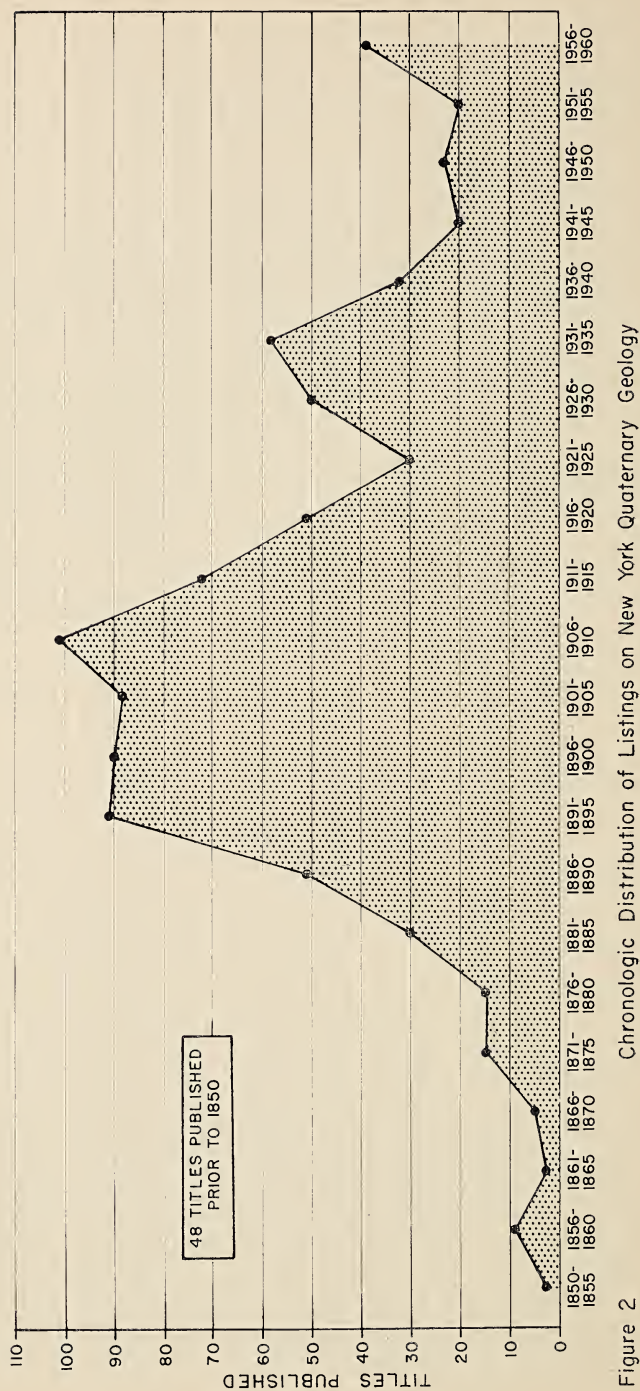


Figure 2

RECENT DECADES: 1921-1962

Although research in New York glacial geology decreased in quantity following the First World War, the impetus of the golden years continued to be felt. Veteran workers continued in the field, and results of investigations begun long before were published. Fairchild had first published on the drumlin belt in 1907, but his ultimate paper on this subject did not appear until 1929, the same year as Slater's study of drumlin structures in Ontario shore bluffs. John L. Rich had first reported work in the Catskills with preliminary notes and abstracts from 1914 to 1918, but his principal report was not published until 1935. During this period, too, Leverett and Taylor published the ultimate refinement of moraine and proglacial lake strandline correlation studies initiated nearly 40 years earlier. A major advance in developing chronology of late glacial times came with Antevs' consummation of varve studies commenced many years previously by De Geer, Antevs, and others.

Important progress was made in several other lines of investigation. From early colonial days, vertebrate fossil finds had been randomly recorded, but a systematic summary record was published as New York State Museum Bulletins in 1922 and 1926. Investigations in New England had led to recognition that glacier retreat in areas of moderate relief occurs typically by downwasting and stagnation rather than by backwasting. A series of studies by John H. Cook from 1922 to 1946 in eastern New York elaborated on features and processes in development of topography by melting of stagnant ice.

Investigation of erosion surfaces in the less intensively glaciated parts of the State commenced with the work of William M. Davis (1891) and Campbell (1903), but received new attention during the early post-Depression years with the work of Fridley (1929), Ver Steeg (1932), and Douglas Johnson (1931) and an historical review by Bryan and others (1935). This investigation reached its culmination in a series of papers by Cole from 1935 to 1941, progressively tracing erosion surfaces of northeastern Ohio, northwestern Pennsylvania, and New York by means of projected profiles, quadrangle by quadrangle. Although Crowl subsequently applied similar interpretation in the Adirondacks (1950), Ashley in 1935 had already expressed a skepticism which increasingly creeps into reference to peneplain analysis.

MacClintock and Apfel in 1944 and MacClintock in 1954 proposed empirical criteria for differentiation of Wisconsin drifts in New York.

In an important investigation of drift dispersion in the Southern New York section of the Appalachian Plateaus, Holmes (1952) mapped lateral variation in till constitution within drift sheets. This theme has been further developed in succeeding studies by Merritt and Muller (1959), Moss and Ritter (1962), and Denny and Lyford (in preparation).

Development of apparatus for counting low level radioactivity led to application of radiocarbon analysis for the dating of fossil organic material. The chronology and correlations resulting from radiocarbon dating (Flint, 1953; Hough, 1958) are not entirely in harmony with the earlier developed varve chronology of Antevs.

A chart of research productivity, measured by numbers of titles per 5-year interval in the accompanying bibliography (figure 2), suggests marked dependence of productivity on external political and economic factors. Although fundamental research continued during the 1920's, the postwar drop in output intensified in the first half of the decade. A similar lag caused the rise of the later 20's to reach its crest in the 30's during the peak of the Depression. The post-Depression slump merged with the lean years of World War II. Recovery in postwar years has been very sluggish in spite of the general boom in scientific investigation.

It is difficult in close perspective to analyze factors responsible for present sluggishness in Quaternary research. Undoubtedly, a principal factor is a decrease among investigators engaged in this field. Modern mobility permits academic workers to undertake field work in areas far from New York. At the same time it accounts for recent publications by British (Sissons, 1960), French (Charlier, 1958), and German (Hanefeld, 1960) investigators reporting basic research in New York.

The increased expense of equipment and sophistication of techniques employed in geologic research likewise afford mixed blessings. Radiocarbon age determinations, palynologic studies, and X ray analyses require equipment, skills, and time which are beyond the ready grasp of many geologists. Punch card and computer techniques which are utilized more and more routinely in other fields of research are almost unknown in Quaternary investigations. The possibilities which recently developed techniques and equipment open up cannot readily be attained by the individual researcher. Academic investigators of geologic problems can no longer permit team research to remain the monopoly of State and Federal surveys. Regretfully it must also be conceded that much which must be attempted and learned requires the concentrated energy of sponsored and directed research above and beyond random individual curiosity.

Bibliography

EXPLANATORY NOTE

The following bibliography of New York Quaternary geology includes approximately 900 titles of published papers. It does not include general listing of water supply papers, soil survey bulletins, land classification studies, and other similar specialized series of publications which may be of use in various aspects of Quaternary research. Nor does it include geologic theses. A separate, unindexed and unevaluated list of theses on New York Quaternary geology is attached as Appendix I.

Titles in the bibliography are listed alphabetically by author's surname. Several titles by one author are arranged chronologically. Several papers by one author and appearing in the same year are listed alphabetically by the first principal word in the title. A title or part of a title in brackets is explanatory and is not copied from the original publication.

Abstracts published separately from articles of the same name are listed separately. Although subject matter is ostensibly that of the principal article, the fact of separate publication permits the possibility of evolution in thought or conclusion which makes separate listing desirable.

An abbreviated title is used in the bibliography for most periodicals. Abbreviated titles commonly used in this bibliography are listed below. Other titles, together with date and place of publication, are given fully enough to be self-explanatory.

ABBREVIATED TITLES FOR COMMONLY CITED SERIALS

The following are abbreviated titles for periodicals and serials used in the Bibliography of New York Quaternary Geology. The complete title, as given in library catalogues, and the place of publication is listed following the abbreviated title. Guidebooks, transactions, and similar publications are identified in the bibliography under the name of the editor or issuing society, with date and location of the congress or symposium for which they were prepared.

- Acad. Nat. Sci. Phila. Proc. — *Academy of Natural Sciences of Philadelphia, Proceedings*. Philadelphia, Pa.
- A.I.M.E. Tr. — *American Institute of Mining Engineers* (later American Institute of Mining, Metallurgical and Petroleum Engineers), *Transactions*. New York
- Albany Inst., Tr. — *Albany Institute, Transactions*. Albany
- Am. Acad. Arts, Mem. — *American Academy of Arts and Sciences, Memoirs*. Boston, Mass.
- Am. Assoc. Adv. Sci. Proc. — *American Association for the Advancement of Science, Proceedings*. Washington, D.C.
- Am. Geog. Soc. Bull.: Res. Ser. — *American Geographical Society of New York Bulletin: Research Series*. New York
- Am. Geologist — *American Geologist*. Minneapolis, Minn.
- Am. Jour. Agri. — *American Journal of Agriculture and Science*. Albany
- Am. Jour. Sci. — *American Journal of Science*. New Haven, Conn.
- Am. Naturalist — *American Naturalist*. Salem, Mass., and elsewhere
- Am. Philos. Soc. Proc. — *American Philosophical Society, Proceedings*. Philadelphia, Pa.
- Am. Scenic and Hist. Preservation Soc. Ann. Rep. — *American Scenic and Historic Preservation Society, Annual Report*. Albany
- Am. Water Works Assoc. Jour. — *American Water Works Association Journal*. New York
- Appalachia — *Appalachia*. Boston, Mass., and Brattleboro, Vt.
- Assoc. Am. Geog. Annals — *Association of American Geographers, Annals*. Washington, D.C.
- Assoc. Am. Geol. and Nat. Rep. — *Association of American Geologists and Naturalists, Reports*. Philadelphia, Pa.
- Beach Erosion Bd., Tech. Mem. — Beach Erosion Board, Office of the Chief of Engineers, Technical Memorandum series, U.S. Army. Washington, D.C.

- Boston Jour. Nat. Hist. — *Boston Journal of Natural History*. Boston, Mass.
- Boston Soc. Nat. Hist. Proc. — *Boston Society of Natural History. Proceedings*. Boston, Mass.
- Brit. Assoc. Adv. Sci. Rep. — *British Association for the Advancement of Science, Report*. London, England
- Buffalo Soc. Nat. Sci. Bull. — *Buffalo Society of Natural Sciences, Bulletin*. Buffalo
- Can. Geol. Survey Sum. Rep. — *Canada, Geological Survey, Summary Report*. Ottawa, Canada
- Can. Inst. Trans. — *Canadian Institute, Transactions*. Toronto, Canada
- Can. Naturalist — *Canadian Naturalist and Geologist and Proceedings of the Natural History Society of Montreal*. Montreal, Canada
- Can. Rec. Sci. — *Canadian Record of Science*. Montreal, Canada
- Columbia Univ. School of Mines Quart. — *Columbia University School of Mines Quarterly*. New York
- Compass — *The Compass*, Sigma Gamma Epsilon, National Earth Science Honorary Society. Provo, Utah, and elsewhere
- Conservationist — *The Conservationist*, New York State Conservation Commission. Albany
- Denison Univ. Sci. Lab. Bull. — *Denison University, Scientific Laboratories Bulletin*. Granville, Ohio
- Deutsche Geol. Gesellschaft Zeits. — *Deutsche Geologische Gesellschaft, Zeitschrift*. Berlin, Germany
- Ecol. Mono. — *Ecological Monographs*. Durham, N.C.
- Econ. Geol. — *Economic Geology*. Urbana, Ill., and elsewhere
- Edinburgh Nat. Phil. Jour. — *Edinburgh Philosophical Journal* (later *Edinburg New Philosophical Journal*). Edinburgh, Scotland
- Eng. Mining Jour. — *Engineering and Mining Journal*. New York
- Friends of the Pleistocene — Friends of the Pleistocene, Eastern Section; guidebooks for dates and meeting places as indicated
- Geog. Annaler — *Geografiska Annaler*. Stockholm, Sweden
- Geog. Rev. — *Geographical Review*. New York
- Geog. Soc. Phila. Bull. — *Geographical Society of Philadelphia Bulletin*. Philadelphia, Pa.
- Geol. Mag. — *Geological Magazine*. London, England
- Geol. Soc. America Bull. : Proc. — *Geological Society of America Bulletin: Proceedings*. New York
- Harvard Coll. Mus. Comp. Zoology Bull. — *Harvard College, Museum of Comparative Zoology Bulletin*. Cambridge, Mass.
- Hobbies — *Hobbies*, later *Science on the March*, Buffalo Museum of Science. Buffalo
- Ind. Acad. Sci. Proc. — *Indiana Academy of Science, Proceedings*. Indianapolis, Ind.

- INQUA — *Congress, International Association for Quaternary Research; Actes*. Abstracts for dates and meeting places as indicated
- International Geographic Union — Congress held on date and at location listed
- Int. Geol. Congress — International Geological Congress; Guidebook. Report for dates and meeting places as indicated
- Jour. Geog. — *Journal of Geography*. Lancaster, Pa., and elsewhere
- Jour. Geol. — *Journal of Geology*. Chicago, Ill.
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- Kentucky Acad. Sci. Trans. — *Kentucky Academy of Sciences Transactions*. Lexington, Ky.
- La Geographie — *La Geographie*. Paris, France
- Lyceum Nat. Hist. New York Ann., Proc.—*Lyceum of Natural History of New York* (later New York Academy of Sciences) *Annals, Proceedings*. New York
- Mag. Nat. Hist. — *Magazine of Natural History* (London). London, England
- Minn. Geol. Survey Ann. Rep. — *Minnesota Geological and Natural History Survey, Annual Report*. Minneapolis, Minn.
- Monthly Am. Jour. Geol. — *Monthly American Journal of Geology and Natural Science*. Philadelphia, Pa.
- Nat. Sci. Assoc. Staten Island Proc. — *Natural Science Association of Staten Island, Proceedings*. New York
- Nature Magazine — *Nature Magazine*. Washington, D.C.
- Nautilus — *The Nautilus*. Philadelphia, Pa.
- N.J. Geol. Survey Ann. Rep. — *New Jersey Geological Survey Annual Report*. Trenton, N.J.
- N.Y. Acad. Sci. Annals; Trans. — *New York Academy of Science Annals; Transactions*. New York
- N.Y. Bot. Garden Jour. — *New York Botanical Garden Journal*. New York
- N.Y. Comm. State Reservation Niagara Ann. Rep. — *New York (State) Commissioners of the State Reservation at Niagara, Annual Report*. Albany
- N.Y. State Agric. Soc. Trans. — *New York State Agricultural Society, Transactions*. Albany
- N.Y. State Cab. Ann. Rep. — *New York State Cabinet of Natural History, Annual Report of the Regents of the University*. Albany
- N.Y. State Geol. Assoc. — *New York State Geological Association, Guidebook*, for dates and meeting places as indicated
- N.Y. State Geol. Ann. Rep. — *New York State Geologist, Annual Report*. Albany
- N.Y. State Mus. Ann. Rep.; Rep. Sci. Dir., — *New York State Museum of Natural History, Annual Report; Report of the Science Director*. Albany

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- N.Y. Water Power and Control Comm. Bull. — *New York Water Power and Control Commission Bulletin*. Albany
- Ohio Jour. Sci. — *Ohio Journal of Science*. Columbus, Ohio
- Pan-Am. Geologist — *Pan-American Geologist*. Des Moines, Iowa
- Penn. Geol. Survey (2d) Ann. Report — *Pennsylvania Geological Survey, Second Annual Report*. Harrisburg, Pa.
- Ph. Mag. — *Philosophical Magazine* (later *London and Edinburgh Philosophical Magazine*; later *London, Edinburgh, and Dublin Philosophical Magazine*)
- Pop. Sci. Monthly — *Popular Science Monthly*. New York
- Pottsville Sci. Asso. Bull. — *Pottsville Scientific Association Bulletin, Schuylkill County, Bulletin*. Pottsville, Pa.
- Quart. Jour. Sci. — *Quarterly Journal of Science*. London, England
- Records of the Past — *Records of the Past*. Washington, D.C.
- Rochester Acad. Sci. Proc. — *Rochester Academy of Science, Proceedings*. Rochester
- Rocks and Minerals — *Rocks and Minerals*. Peekskill
- Roy. Soc. Canada Proc. and Trans. — *Royal Society of London, Proceedings and Transactions*. Montreal, Canada
- Science — *Science*, Lancaster, Pa.
- Science on the March — *Science on the March* (earlier *Hobbies*), *Buffalo Museum of Science*. Buffalo
- Sci. American — *Scientific American*. New York
- Sci. Am. Supplement — *Scientific American Supplement*. New York
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- Smithsonian Cont. to Knowledge — *Smithsonian Institution Contributions to Knowledge*. Washington, D.C.
- Soc. Sciences Naturelles de Neuchatel — *Societe des Sciences Naturelles de Neuchatel Bulletin*. Neuchatel, Switzerland
- Staten Island Assoc. Proc. — *Staten Island Association of Arts and Sciences, Proceedings*. New York
- U.S. Geol. Survey Geol. Atlas; Prof. Paper; Monograph; Water Supply Paper — *United States Geological Survey, Geological Atlas Folia; the Professional Papers; Monograph; Water Supply Paper*. Washington, D.C.
- Vassar Bros. Inst. Trans. — *Vassar Brothers Institute, Transactions*. Poughkeepsie
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Happ, Stafford C., 1938b
Harris, T. W., 1894
Hollick, Charles A., 1899a, 1900
Holmes, Chauncey D., 1946, 1947
Holzwasser, Florrie, 1926
Kellogg, D. S., 1892
Kemp, James F., 1910
Kemp, James F. (with Alling, Harold L.), 1925
La Fleur, Robert G., and others, 1961
Merrill, F. J. H., 1890
Miller, William J., 1909a, 1909c, 1910, 1914, 1917b, 1919a, 1926
Moss, John H. (with Ritter, Dale F.), 1962
Muller, Ernest H., 1957c
Ogilvie, Ida H., 1902a, 1902b
Peet, Charles E., 1894, 1904
Rich, John L., 1915b, 1935, 1941, 1943
Sissons, J. B., 1960
Spencer, Joseph W. W., 1890a
Stewart, David P., 1958
Stoller, James H., 1911, 1916, 1919a, 1919b, 1920, 1922a, 1922b, 1932
Tarr, Ralph S., 1896b, 1902
Tomlinson, C. H., 1832

Upham, Warren E., 1892b, 1893
Veatch, Arthur C., 1903
Williams, Henry S., and others, 1909
Woodworth, Jay B., 1893, 1901, 1905a, 1905b

34. Moraine features

Agassiz, Louis, 1864
Alden, William C., 1903a, 1903b, 1918
Alling, Harold L., 1916
Antevs, Ernst, 1929
Apfel, Earl T., 1931, 1932a
Bailey, Paul, 1959
Baldwin, S. Prentiss, 1894
Brigham, Albert P., 1908, 1910, 1911, 1914, 1929
Britton, Nathaniel L., 1887, 1888
Bryson, John, 1883, 1885, 1888, 1891a, 1891b, 1892,
1893a, 1893b, 1893c, 1894, 1895a, 1895b, 1896, 1897,
1898
Carney, Frank, 1903, 1907a, 1907c, 1909c
Chadwick, George H., 1924
Chamberlin, Thomas C., 1883
Chapman, Donald H., 1942
Claypole, Edward W., 1879, 1882
Cook, John H., 1922, 1924, 1945
Cushing, Henry P., 1905b, 1907, 1916
Cushing, Henry P., and others, 1910
Dana, James D., 1887
Denny, Charles S., 1954, 1956
Dewey, Chester, 1843
Dryer, Charles R., 1890
Durham, Forrest, 1958
Edson, Obed, 1884
Engeln, O. D. von, 1921, 1926, 1938, 1945, 1961
Fairchild, Herman L., 1895e, 1895f, 1896a, 1897a,
1900b, 1902c, 1909a, 1909e, 1912a, 1912b, 1913b,
1923, 1925a, 1926a, 1926b, 1926d, 1928, 1932a, 1932b,
1932c, 1932d, 1932e
Fleming, W. L. S., 1935
Flint, Richard F., 1953
Fox, Jay T., 1946
Fuller, Myron L., 1914
Gilbert, Grove K., 1901
Gratacap, Louis P., 1899
Hanefeld, Horst, 1960
Happ, Stafford C., 1938b
Heubusch, Carol A., 1958
Hollick, Charles A., 1886, 1894, 1899b, 1899c, 1900,
1901
Holmes, Chauncey D., 1935, 1937, 1946, 1952, 1959
Johnson, Douglas W., 1917a, 1917b
Johnson, Laurence, 1882a

- Kay, G. Marshall, 1953
Kellogg, D. W., 1892
Kemp, James F., 1910
Kemp, James F. (with Alling, Harold L.), 1925
Kindle, Cecil H., 1946
Kindle, Edward M. (with Taylor, Frank B.), 1913
Koenig, Martin (with Lombard, Paul A.), 1937
La Fleur, Robert G., and others, 1961
Leverett, Frank, 1892a, 1892b, 1895, 1898, 1902, 1939
Leverett, Frank (with Taylor, Frank B.), 1915
Lewis, Henry C., 1884
Lobeck, Armin K., 1918, 1927a, 1927b
Lowe, Kurt E., and others, 1958
MacClintock, Paul, 1954, 1958
MacClintock, Paul (with Apfel, Earl T.), 1944
Merrill, F. J. H., 1886a, 1886b
Miller, William J., 1919a, 1926
Moss, John H. (with Ritter, Dale F.), 1962
Muller, Ernest H., 1957b, 1957c, 1960
Ogilvie, Ida H., 1902b
Peet, Charles E., 1904
Redfield, William C., 1847
Rich, John L., 1906, 1915b, 1917, 1918, 1935, 1943
Rosalsky, Maurice B., 1947
Salisbury, Rollin D. (with Darton, Nelson H.), 1908
Sissons, J. B., 1960
Smock, John C., 1885
Spencer, Joseph W. W., 1891b, 1898c
Stevens, Richard P., 1872
Stewart, David P., 1958
Stoller, James H., 1916
Tarr, Ralph S., 1896b, 1902, 1905e, 1905f
Taylor, Frank B., 1897a, 1897b, 1912, 1924, 1925a, 1925b, 1925c, 1931b, 1931c, 1932, 1939
Upham, Warren E., 1879, 1889, 1893
Veatch, Arthur C., 1903a, 1903b, 1906
Wells, John W., and others, 1949, 1958
Whitnall, Harold O., 1945
Williams, Henry S., and others, 1909
Wood, Albert E., 1948
Woodworth, Jay B., 1901
35. Fluvioglacial features
Alden, William C. (with Fuller, Myron L.), 1903b
Alling, Harold L., 1916
Bailey, Paul, 1959
Barker, Elmer E., 1913
Brigham, Albert P., 1896, 1897, 1898b, 1898c, 1911, 1915, 1929, 1931
Britton, Nathaniel L., 1882, 1888
Bryson, John, 1883, 1885, 1892, 1893a, 1893b, 1893c, 1894, 1895a, 1895b, 1896, 1897, 1898

- Carney, Frank, 1907a, 1908, 1909c
Chadwick, George H., 1928a, 1928d, 1928e, 1931
Chapman, Donald H., 1942
Cook, John H., 1942
Cushing, Henry P., 1907
Cushing, Henry P., and others, 1910
Dana, James D., 1887
Denny, Charles S., 1954
Dryer, Charles R., 1908b
Engeln, O. D. von, 1921, 1945, 1961
Fairchild, Herman L., 1902a, 1902b, 1904c, 1911a,
1920a, 1925b, 1926
Fuller, Myron L., 1903a, 1914
Fuller, Myron L. (with Veatch, Arthur C.), 1903c
Goldthwait, Joseph W., 1913
Hanefeld, Horst, 1960
Happ, Stafford C., 1938b
Holmes, Chauncey D., 1946
Hopkins, Thomas C., 1914a
Julien, Alexis A., 1906
Kay, G. Marshall, 1953
Kellogg, D. S., 1892
Kemp, James F., 1906
Kindle, Cecil H., 1946
Leverett, Frank, 1902
Lewis, Elias, Jr., 1877a, 1877b
Lloyd, T. C. B., 1877a, 1877b
Lobeck, Armin K., 1927b
Lowe, Kurt E., and others, 1958
MacClintock, Paul (with Terasmae, Jaan), 1960
Merrill, F. J. H., 1891
Miller, William J., 1910, 1911b
Mills, Frank S., 1903
Moss, John H. (with Ritter, Dale F.), 1962
Muller, Ernest H., 1957c
Ogilvie, Ida H., 1902a, 1902b
Peet, Charles E., 1904
Rich, John L., 1908, 1935, 1943
Rosalsky, Maurice B., 1947
Sissons, J. B., 1960
Spencer, Joseph W. W., 1892a, 1912a, 1912b
Stoller, James H., 1916, 1929, 1932
Tarr, Ralph S., 1896b, 1902
Taylor, Frank B., 1892
Tomlinson, C. H., 1832
Upham, Warren E., 1892b
Vanuxem, Lardner, 1842
Veatch, Arthur C., 1903a, 1903b, 1906
Watson, Winslow C., 1859
Williams, Henry S., and others, 1909
Woodworth, Jay B., 1901, 1905b

36. Proglacial lake features

- Alden, William C. (with Fuller, Myron L.), 1903b
Alling, Harold L., 1916
Apfel, Earl T., 1946
Baker, Manley B. (with Johnson, A. W.), 1924
Baldwin, S. Prentiss, 1894
Barker, Elmer E., 1916
Bartram, John, 1751
Bishop, Irving P., 1897
Brigham, Albert P., 1911, 1931
Carney, Frank, 1907d, 1908
Chadwick, George H., 1910, 1923, 1928d, 1928e
Chadwick, George H. (with Dunbar, E. U.), 1924
Chalmers, Robert, 1895, 1896, 1904
Chapman, Donald H., 1937, 1942
Claypole, Edward W., 1879, 1882
Coleman, Arthur P., 1899, 1905
Cook, John H., 1924, 1942, 1943
Cushing, Henry P., and others, 1910
Cushing, Henry P. (with Newland, David H.), 1925
Davis, William M., 1891
Davis, William M. (with Wood, J. W., Jr.), 1890
Desor, Edouard, 1850b, 1850c
Dryer, Charles R., 1908a
Edson, Obed, 1884
Engeln, O. D. von, 1921, 1926, 1945, 1961
Fairchild, Herman L., 1895b, 1895c, 1895d, 1895g,
1896b, 1896c, 1897a, 1897b, 1897c, 1898a, 1898b,
1899a, 1899b, 1899c, 1900c, 1900d, 1900f, 1901,
1902a, 1902b, 1902c, 1903, 1904d, 1904e, 1905c,
1906a, 1907d, 1907e, 1909a, 1909c, 1909d, 1909e,
1911a, 1912c, 1913a, 1913b, 1914a, 1916a, 1916b,
1919b, 1920a, 1920b, 1925a, 1925b, 1926a, 1926b,
1926c, 1928, 1932a, 1932b, 1932c, 1932d, 1932e,
1934a, 1934b, 1935b, 1935c
Flint, Richard F., 1953
Fuller, Myron L., 1903a
Gilbert, Grove K., 1885, 1888a, 1888b, 1897a, 1898b
Grabau, Amadeus W., 1901
Gratacap, Louis P., 1901
Hall, James, 1838
Happ, Stafford C., 1938b
Hopkins, Thomas C., 1910, 1914a
Hough, Jack L., 1958
Johnson, Laurence, 1882a
Kay, G. Marshall, 1953
Kellogg, D. S., 1892
Kemp, James F., 1906
Kemp, James F. (with Alling, Harold F.), 1925
Kindle, Edward M. (with Taylor, Frank B.), 1913
Koenig, Martin (with Lumbard, Paul A.), 1937

- La Fleur, Robert G., and others, 1961
 Leverett, Frank, 1902, 1939
 Leverett, Frank (with Taylor Frank B.), 1915
 Lincoln, D. F., 1895a
 Lobeck, Armin K., 1927b
 Lowe, Kurt E., and others, 1958
 MacClintock Paul, 1958
 Miller, William J., 1909c, 1910, 1911b, 1914, 1916,
 1917b, 1919a, 1924, 1925a, 1925b, 1926
 Muller, Ernest H., 1960
 Myers, Richmond E., 1946
 Nevius, J. Nelson, 1899
 Newberry, John S., 1882, 1889
 Ogilvie, Ida H., 1902a, 1902b
 Reeds, Chester A., 1927, 1928
 Rich, John L., 1915b
 Rodgers, John, 1937
 Salisbury, Rollin D., 1908
 Sissons, J. B., 1960
 Spencer, Joseph W. W., 1882, 1883, 1887, 1888a, 1888b,
 1890a, 1890b, 1890c, 1890d, 1891a, 1891b, 1891c,
 1892b, 1894b, 1894f, 1898e, 1900, 1907
 Stoller, James H., 1916, 1919a, 1919b, 1920, 1922a,
 1922b, 1932
 Tarr, Ralph S., 1896a, 1896b, 1902
 Taylor, Frank B., 1897a, 1910a, 1913b, 1939
 Upham, Warren E., 1892a, 1892c, 1896a, 1896b, 1903a,
 1905
 Vanuxem, Lardner, 1842
 Watson, Thomas L., 1899
 Wells, John W., and others, 1949, 1958
 White, George W., 1953
 Whittlesey, Charles L., 1850
 Willard, Bradford, 1932a, 1932b
 Woodworth, Jay B., 1905a, 1905b
 Wright, George F., 1890

4. Nonglacial geomorphology

41. Erosion surfaces and peneplanation

- Alden, William C. (with Fuller, Myron L.), 1903a,
 1903b
 Ashley, G. H., 1935
 Berkey, Charles P., 1921
 Blume, Helmut, 1952
 Brigham, Albert P., 1914
 Bryan, Kirk, and others, 1935
 Campbell, Marius E., 1903a, 1903b, 1904
 Carney, Frank, 1909c
 Claypole, Edward W., 1877, 1879, 1882
 Coates, Donald R., 1959

- Cole, W. Storrs, 1935, 1937a, 1938, 1941a, 1941b
Crowl, George H., 1950
Cumings, Edgar R., 1899
Cushing, Henry P., 1905, 1916
Cushing, Henry P., and others, 1910
Cushing, Henry P. (with Newland, David H.), 1925
Dale, Nelson C., 1935
Davis, William M., 1889, 1891b
de Laguna, Wallace, and others, 1946
Engeln, O. D. von, 1961
Finch, John, 1835
Fluhr, Thomas W., 1962
Fridley, Harry M., 1929, 1935
Gilbert, Grove K., 1897b
Goldring, Winifred, 1933
Gordon, Clarence E., 1911
Grabau, Amadeus W., 1901a, 1920
Hanefeld, Horst, 1960
Happ, Stafford C., 1938a
Hartnagel, Chris A., 1940
Hayes, George F., 1839
Hopkins, Thomas C., 1914a
Johnson, Douglas W., 1931b, 1931c
Kemp, James F., 1906
Lobeck, Armin K., 1918, 1927b
Mackin, J. Hoover, 1933
Miller, William J., 1920, 1924, 1926
Muller, Ernest H., 1960, 1961
Nevius, J. Nelson, 1899
Newberry, John S., 1874
Ogilvie, Ida H., 1902b
Peet, Charles E., 1904
Perlmutter, Nathaniel M., 1949
Quereau, Edmund C., 1898
Rich, John L., 1915b, 1918, 1935, 1939
Simpson, Eugene S., 1952
Sissons, J. B., 1960
Spencer, Joseph W. W., 1882, 1889, 1890e, 1890f
Stoller, James H., 1911
Tarr, Ralph S., 1896, 1902
Upham, Warren E., 1890
Ver Steeg, Karl, 1932
Wells, John W., and others, 1949, 1958
White, George W., 1953
Williams, Henry S., and others, 1909
Winchell, Alexander N., 1897
42. Valley features and stream processes
Alden, William C. (with Fuller, Myron L.), 1903a,
1903b
Bakewell, Robert, 1830, 1847, 1857

- Ballou, William H., 1882
Belt, Thomas, 1875
Berkey, Charles P., 1906, 1911a, 1913
Bishop, Irving P., 1897
Brigham, Albert P., 1914
Burroughs, Wilbur G., 1933
Carll, John F., 1880
Carney, Frank, 1903, 1904
Chadwick, George H., 1917
Clarke, John M., 1915
Claypole, Edward W., 1877, 1879, 1882, 1886a, 1886b, 1889
Coates, Donald R., 1959
Cole, W. Storrs, 1930, 1937b
Cook, John H., 1909
Cressey, George B., 1935
Crosby, William O., 1914
Cumings, Edgar R., 1899
Cushing, Henry P., 1901, 1905b, 1907, 1916
Cushing, Henry P., and others, 1910
Dana, James D., 1863, 1890
Darton, Nelson H., 1896
Davis, William M., 1889
Desor, Edouard, 1853, 1854
Dryer, Charles R., 1890, 1904a, 1904b, 1906
Engeln, O. D. von, 1929a, 1931b, 1933, 1936, 1940, 1945, 1952, 1961
Fairchild, Herman L., 1903, 1904a, 1904c, 1905b, 1905c, 1906b, 1907d, 1907e, 1909b, 1909c, 1909d, 1911b, 1912a, 1912b, 1912c, 1913a, 1913b, 1914a, 1919b, 1925a, 1925b, 1928, 1935a, 1935b
Fairholme, George, 1834
Featherstonhaugh, George W., 1831, 1845
Fleming, Mary A., 1899
Flint, Richard F., 1953
Foot, Lyman, 1822
Forrester, Glenn C., 1926, 1928
Fuller, Myron L., 1903a
Gibbes, Lewis R., 1857a, 1857b
Gibson, John, 1836
Gilbert, Grove K., 1886a, 1890, 1894, 1895, 1896a, 1896b, 1897b, 1901a, 1901b, 1907, 1908
Goldring, Winifred, 1933
Gordon, Clarence E., 1911
Grabau, Amadeus W., 1894, 1901a, 1901b, 1907, 1908a, 1908b, 1908c, 1909a, 1909b, 1913a, 1913b, 1918, 1920
Gunning, W. D., 1872
Hall, James, 1842, 1857
Hall, W. Carvel, 1907
Hallett, P., 1885
Happ, Stafford C., 1938a

- Hartnagel, Chris A., 1940
Hayes, George F., 1839
Hitchcock, Charles H., 1901
Hobbs, William H., 1903, 1905a, 1905b, 1905c
Holley, George W., 1872, 1874
Holmes, Chauncey D., 1935a, 1935b
Hopkins, Thomas C., 1910, 1914b
Hubbard, Oliver P., 1889
Hyatt, Alpheus, 1869
Johnson, Douglas W., 1931a, 1931b, 1931c
Johnson, William A., 1928
Julien, Alexis A., 1881, 1910
Kemp, James F., 1896, 1897, 1901, 1905, 1906, 1907a, 1907b, 1908, 1909, 1912
Kemp, James F. (with Alling, Harold L.), 1925
Kindle, Edward M. (with Taylor, Frank B.), 1913
Kirk, Edwin, 1932
Leverett, Frank, 1902
Lobeck, Armin K., 1927b
Long, Eleanor T., 1926
Mackin, J. Hoover, 1933
Marcou, Jules, 1865
Martin, Lawrence, 1915
Matson, George C., 1904
Merrill, F. J. H., 1890a, 1900
Miller, William J., 1909a, 1911b, 1917a, 1917b, 1919b, 1921, 1924, 1926
Mills, Frank S., 1903
Muller, Ernest H., 1957a
Ogilvie, Ida H., 1902a, 1902b
Osborn, Henry F., 1900
Peet, Charles E., 1904
Pohlman, Julius, 1883, 1886, 1889
Pollack, Henry, 1958
Pyncheon, W. H. C., 1895
Quereau, Edmund C., 1898
Ramsay, Andrew C., 1859
Redfield, William C., 1838
Rich, John L., 1908, 1915a, 1915b, 1935
Roberts, Thomas P., 1880
Rogers, Brownell, 1893
Rogers, Henry D., 1835
Ruedemann, Rudolph, 1931, 1932
Scovell, Josiah T., 1889a, 1891
Shaler, Nathaniel S., 1893
Simonds, F. W., 1877, 1894
Simpson, Eugene S., 1949, 1952
Spencer, Joseph W. W., 1881, 1882, 1887a, 1890e, 1890f, 1894a, 1894b, 1894c, 1894d, 1895, 1896, 1898a, 1898b, 1898c, 1898d, 1904, 1905a, 1905b, 1907a, 1907b, 1907c, 1908a, 1908b, 1908c, 1908d, 1908e,

1908f, 1908g, 1908h, 1910a, 1910b, 1910c, 1910d,
1910e, 1912a, 1912b, 1913, 1914, 1915, 1916, 1917
Stoller, James H., 1911, 1916, 1930
Tarr, Ralph S., 1896b, 1902, 1904, 1905a, 1905b, 1905c,
1905d, 1906b, 1906c
Taylor, Frank B., 1895, 1897a, 1898a, 1898b, 1898c,
1913a, 1913c, 1914, 1925c, 1930
Thompson, Henry D., 1936a, 1936b
Tyndall, John, 1873
Upham, Warren E., 1894, 1898a, 1898b, 1901, 1903b,
1905, 1908
Whitbeck, Roy H., 1902
Wilson, Alice E., 1946
Winchell, Alexander N., 1897
Wold, John S., 1942
Wood, Albert E., 1948
Woodward, Robert S., 1886a, 1886b
Worzel, John L. (with Drake, Charles L.), 1959
Wright, George F., 1884a, 1884b, 1890, 1895, 1898a,
1899a, 1899b, 1905, 1921

43. Shore features and processes

Alden, William C., 1918a
Bailey, Paul, 1959
Baldwin, S. Prentiss, 1894
Brigham, Albert P., 1893
Bryson, John, 1888b, 1891, 1893a, 1893b, 1893c, 1895
Chalmers, Robert, 1896
Chapman, Donald H., 1942
Charlier, Roger H., 1958
Claypole, Edward W., 1886
Coleman, Arthur P., 1917
Cook, Edward H., 1857a, 1857b
Dana, James D., 1890
Davis, William M., 1891b, 1892, 1893
Fairchild, Herman L., 1911a, 1914b, 1934c
Fox, Jay T., 1946
Goldthwait, Joseph W., 1913
Hanefeld, Horst, 1960
Johnson, Douglas W., 1925, 1930
Kemp, James F., 1909
Kindle, Edward M., 1921
Kindle, Edward M. (with Taylor, Frank B.), 1913
Leverett, Frank, 1892a, 1892b, 1895, 1898, 1902
Lewis, Elias, Jr., 1868, 1877c
Lindenkohl, A., 1891
MacClintock, Paul, 1958
Martin, J. O., 1901
Mather, Kirtley F., 1917
Merrill, F. J. H., 1890a, 1890c, 1891
Miller, William J., 1909a, 1917a

- Ramsay, Andrew C., 1858, 1859
Rosalsky, Maurice B., 1949, 1950
Spencer, Joseph W. W., 1891a, 1891c, 1894b, 1905a, 1905b, 1916, 1917
Stoller, James H., 1911, 1919a, 1919b, 1929
Taber, Stephen, 1950
Taney, Norman E., 1961
Tarr, Ralph S., 1896b, 1902
Taylor, Frank B., 1895, 1897b, 1898a, 1913b, 1927c
Terasmae, Jaan, 1959
Upham, Warren E., 1892a
Whitnall, Harold O., 1945
Whittlesey, Charles L., 1850, 1866
Wilson, A. W. G., 1908a, 1908b
Woodworth, Jay B., 1905a, 1905b
Young, Arthur E., 1946
44. Structurally controlled topography
Ashley, George H., 1935
Berkey, Charles P., 1913
Blume, Helmut, 1952
Brigham, Albert P., 1898
Bryan, Kirk, and others, 1935
Chadwick, George H., 1916
Cole, W. Storrs, 1930, 1935, 1937a
Cushing, Henry P., 1910
Dale, Nelson C., 1935b
Darton, Nelson H., 1914
Davis, William M., 1882, 1889
de Laguna, Wallace (with Brashears, Maurice L., Jr.), 1946
Engeln, O. D. von, 1961
Fairchild, Herman L., 1919b
Friedman, Jules D., 1957
Gilbert, Grove K., 1891, 1899b, 1899c, 1901a
Goldring, Winifred, 1933
Grabau, Amadeus W., 1901a, 1918, 1920
Hanefeld, Horst, 1960
Heusser, E., 1939
Hobbs, William H., 1903, 1905a, 1905b, 1905c
Julien, Alexis A., 1906, 1907
Kemp, James F., 1901, 1906
Kindle, Edward M. (with Taylor, Frank B.), 1913
Mackin, J. Hoover, 1933
Megathlin, Gerrard R., 1938
Miller, William J., 1924
Muller, Ernest H., 1957c, 1961
Ramsay, Andrew C., 1858
Roorbach, George B., 1913a, 1913b
Ruedemann, Rudolph, 1931
Spencer, Joseph W. W., 1913a, 1913d

Tarr, Ralph S., 1896b, 1902
Thompson, Henry D., 1959
Whitnall, Harold O., 1945
Wold, John S., 1942
Woodworth, Jay B., 1907

45. Gravity-produced and periglacial features

Chadwick, George H., 1935
Claypole, Edward W., 1889
Cushing, Henry P., 1907
Davis, W. C., Jr., 1942
Denny, Charles S., 1938, 1951, 1954, 1956
Dwight, William B., 1886
Hyatt, Alpheus, 1869
Miller, William J., 1915
Muller, Ernest H., 1960
Newland, David H., 1909, 1916a, 1916b
Rosanski, George, 1943
Smith, H. T. U., 1953

46. Features due to ground water action

Apfel, Earl T., 1932
Berdan, Jean M., 1954
Bryson, John, 1888a, 1889
Cushing, Henry P., and others, 1910
Eights, James, 1848
Fairchild, Herman L., 1935b
Fuller, Myron L. (with Veatch, Arthur C.), 1903c
Goldring, Winifred, 1933
Hopkins, Thomas C., 1910, 1914a
Kindle, Edward M., 1905
Perlmutter, Nathaniel M., 1949
Sanford, Edward, 1830
Schmidt, Victor E., 1947
Simpson, Eugene S., 1949, 1952
Tarr, Ralph S., 1904a
Taylor, Frank B., 1905
Upson, Joseph E., 1955
Veatch, Arthur C., 1906

5. Sedimentation and sedimentology

51. Till and drift constitution

Balk, Robert, 1932
Benson, A. B., (*ed.*), 1937
Benton, Edward R., 1878
Bishop, Irving P., 1897
Brigham, Albert P., 1895, 1929
Bryson, John, 1888a, 1889, 1891a, 1892, 1893a, 1895,
1897
Carney, Frank, 1907c, 1909b
Connally, G. Gordon, 1960
Cushing, Henry P., 1905b, 1916

- Delafield, John, 1850
Denny, Charles S., 1956
Dreimanis, Aleksis, 1958, 1960
Eaton, Harry N., 1938
Edson, Obed, 1884
Engeln, O. D. von, 1930
Fargo, J. G., 1875
Fitch, Asa, 1850
Fleming, W. L. S., 1935
Fuller, Myron L. (with Veatch, Arthur C.), 1903c
Gager, Charles S., 1932
Gilbert, Grove K., 1898a
Gratacap, Louis P., 1899
Hall, James, 1843a, 1843b
Happ, Stafford C., 1938
Hayes, George F., 1839
Hitchcock, Charles H., 1898
Hollick, Charles A., 1894, 1898, 1899b, 1899c, 1908, 1915
Holmes, Chauncey D., 1938, 1941, 1958, 1960
Holzwasser, Florrie, 1926
Humphreys, Edwin W. (with Julien, Alexis A.), 1911
Johnson, Laurence, 1882a
Jones, F. O., 1907
Kalm, Peter, 1753
Kay, G. Marshall, 1953
Kemp, James F., 1906
Lewis, Douglas W., 1960
Lewis, Elias, Jr., 1873
Lobeck, Armin, K., 1918
MacClintock, Paul, 1954a, 1954b, 1958
MacClintock, Paul (with Apfel, Earl T.), 1944
Martens, James H. C., 1925
Martin, J. O., 1901
Merritt, Richard S. (with Muller, Ernest H.), 1959
Miller, William J., 1909c, 1916
Moss, John H. (with Ritter, Dale F.), 1962
Muller, Ernest H., 1956, 1960
Perlmutter, Nathaniel M. 1949
Ramsay, Andrew C., 1859
Redfield, William C., 1842
Reed, Stephen, 1873
Schmidt, Victor E., 1947
Stoller, James H., 1911, 1916, 1929, 1932
Taylor, Frank B., 1910b, 1910c
Williams, Henry S., and others, 1909
Wood, Albert E., 1948
52. Alluvial and floodplain sediments
Brigham, Albert P., 1896, 1897
Cole, W. Storrs, 1930, 1937b

- Engeln, O. D. von, 1936
Kindle, Edward M. (with Taylor, Frank B.), 1913
MacClintock, Paul (with Richards, Horace G.), 1936
Stoller, James H., 1920
Williams, Henry S., and others, 1909

53. Nonlittoral lacustrine and marine sediments

- Antevs, Ernst, 1928
Bryson, John, 1895b
Chadwick, George H., 1917
Chapman, Donald H., 1937, 1942
Coleman, Arthur P., 1905
Davis, William M., 1891b
Dwight, William B., 1885a, 1885b
Eggleton, Frank E., 1931
Engeln, O. D. von, 1918, 1931a
Fairchild, Herman L., 1894, 1906a, 1907c, 1914a, 1916a,
1917a, 1917b, 1917c, 1919a, 1920c
Goldring, Winifred, 1922
Goldthwait, Joseph W., 1914
Hough, Jack L. 1958
La Fleur, Robert G., and others, 1961
MacClintock, Paul, 1958
MacClintock, Paul (with Richards, Horace G.), 1936
Merrill, F. J. H., 1889
Peet, Charles E., 1904
Reeds, Chester A., 1923, 1926, 1927, 1928
Rich, John L. 1915, 1935
Richards, Horace G., 1956a, 1956b
Ries, Heinrich, 1891, 1894a, 1894b
Salisbury, Rollin D. (with Darton, Nelson H.), 1908
Smyth, Charles H. 1893
Stoller, James H., 1916, 1920
Stone, George H., 1891
Taney, Norman E. 1961
Tarr, Ralph S., 1904

54. Weathering, soil development, and classification

- Bishop, Irving P., 1897
Denny, Charles S., 1954
Fairchild, Herman L., 1912d
Fitch, Asa, 1850
MacClintock, Paul, 1952, 1954a, 1954b, 1958
MacClintock, Paul (with Apfel, Earl T.), 1944
Merritt, Richard S. (with Muller, Ernest H.), 1959
Miller, William J., 1911a
Peet, Charles E., 1904
Rich, John L., 1935
Smyth, Charles H., 1898a, 1898b

6. Tectonic

61. Isostasy, eustasy, glacitectonics, and other Quaternary faulting or folding

- Berkey, Charles P. (with Rice, Marion), 1921
Chadwick, George H., 1928d
Chalmers, Robert, 1896, 1904
Claypole, Edward W., 1886
Cook, John H., 1943
Fairchild, Herman L., 1907d, 1914b, 1916b, 1916c, 1917d, 1918, 1919a, 1920b, 1926a, 1931
Gilbert, Grove K., 1885, 1886b, 1891, 1895, 1897a, 1898b, 1899a
Goldthwait, Joseph W., 1910
Gordon, Clarence E., 1911
Grabau, Amadeus W., 1920
Hough, Jack L., 1958
Kemp, James F., 1905
Kemp, James F. (with Alling, Harold L.), 1925
Kindle, Edward M. (with Taylor, Frank B.), 1913
Lewis, Elias, Jr., 1868, 1877
Lindenkohl, A., 1891
Lloyd, T. C. B., 1877
Mac Lean, William F., 1961
Merrill, F. J. H., 1886a, 1891
Miller, William J., 1914, 1919a, 1924
Price, Charles A., 1954
Rodgers, John, 1937
Shepard, Francis P., 1937
Spencer, Joseph W. W., 1887b, 1888b, 1890b, 1891a, 1891b, 1894b, 1911, 1913b, 1913c, 1914a
Stoller, James H., 1932
Taylor, Frank B., 1898a, 1910a, 1927a, 1927b, 1927c, 1929
Tuttle, George W., 1904
Upham, Warren E., 1890, 1895
White, George W., 1951, 1953
Woodworth, Jay B., 1905b, 1907

7. Miscellaneous

71. Descriptive and areal studies

- Alden, William C., 1918a, 1918b
Alden, William C. (with Fuller, Myron L.), 1903a, 1903b
Alling, Harold L., 1919a, 1919b, 1921
Balk, Robert, 1932
Bendrat, T. A., 1908
Berkey, Charles P., 1911
Berkey, Charles P. (with Rice, Marion), 1921
Bishop, Irving P., 1897
Brigham, Albert P., 1889, 1929

- Britton, Nathaniel L., 1881
Carney, Frank, 1909c
Chadwick, George H., 1928
Cook, John H., 1930, 1935, 1942, 1943
Cressey, George B., 1941
Crosby, William O., 1900
Cushing, Henry P., 1901, 1905a, 1905b, 1907, 1916, 1918
Cushing, Henry P., and others, 1910
Cushing, Henry P. (with Newland, David H.), 1925
Cushing, Henry P. (with Ruedemann, Rudolph), 1914
Dale, Nelson C., 1935a
Darton, Nelson H., 1894a, 1894b
Delafield, John, 1850
Dryer, Charles R., 1904a, 1904b
Emmons, Ebenezer, 1842
Engeln, O. D. von, 1921, 1961
Fairchild, Herman L., 1895b, 1925a, 1932e
Gilbert, Grove K., 1901a
Goldring, Winifred, 1933
Gordon, Clarence E., 1911
Hall, James, 1843b
Hanefeld, Horst, 1960
Holzwasser, Florrie, 1926
Hopkins, Thomas C., 1914a
Houghton, Frederick, 1914
Kay, G. Marshall, 1953
Kemp, James F. 1910
Kemp, James F. (with Alling, Harold L.), 1925
Kindle, Edward M. (with Taylor, Frank B.), 1913
La Fleur, Robert G., and others, 1961
Leverett, Frank, 1902
Lowe, Kurt E., and others, 1958
Mather, William W., 1843
Merrill, F. J. H., 1886b
Merrill, F. J. H. (with Salisbury, Rollin D.), 1902
Miller, William J., 1909a, 1910, 1914, 1916, 1917a, 1917b, 1919a, 1924, 1926
Muller, Ernest H., 1960
Ogilvie, Ida H., 1902a
Rich, John L., 1915b, 1935
Salisbury, Rollin D., 1908
Shattuck, George B., 1907
Smith, Frances N., 1934
Stewart, David P., 1958
Stoller, James H., 1911, 1916, 1920
Tarr, Ralph S., 1896b, 1902, 1912
Vanuxem, Lardner, 1842
Wells, John W., and others, 1949, 1958
Williams, Henry S., and others, 1909
Woodworth, Jay B. 1901, 1905

72. History of investigations

- Agassiz, Louis, 1864
Bakewell, Robert, 1830, 1847, 1857
Bartram, John, 1751
Benson, A. B. (*ed.*), 1937
Brigham, Albert P., 1914
Bryan, Kirk, and others, 1935
Carney, Frank, 1909a
Darby, William, 1819
Dekay, James E., 1824, 1829
Delafield, John, 1850
Desor, Edouard, 1850a, 1850b, 1850c, 1853, 1854
Dewey, Chester, 1837, 1839, 1843a, 1843b
Eaton, Amos, 1827
Eights, James, 1852
Emmons, Ebenezer, 1842
Fairchild, Herman L., 1898c
Fairholme, George, 1834
Featherstonhaugh, George W., 1831, 1845
Finch, John, 1835
Fitch, Asa, 1850
Foot, Lyman, 1822
Gibbes, Lewis R., 1857a, 1857b
Gibson, John, 1836
Guernsey, J. A., 1831
Hall, James, 1843a, 1843b, 1843c, 1843d
Hayes, George F., 1838a, 1838b
Kalm, Peter, 1753
Lyell, Charles, 1845
Martin, Daniel S., 1899
Mather, William W., 1841, 1843
Miller, Sylvanus, 1836
Ramsay, Andrew C., 1858, 1859
Redfield, William C., 1838, 1842, 1847
Rogers Henry D., 1835
Thomas, David, 1830
Thompson, William A., 1831, 1833
Tomlinson, C. H., 1832
Vanuxem, Lardner, 1842
White, George W., 1951, 1953
Whittlesey, Charles L., 1850, 1866, 1867

73. Quaternary geological maps

- Alden, William C., 1918a, 1918b
Alden, William C. (with Fuller, Myron L.), 1903a, 1903b
Alling, Harold L., 1916
Brigham, Albert P., 1897, 1929
Carney, Frank, 1909c
Chamberlin, Thomas C., 1883
Cook, John H., 1942

Cushing, Henry P., and others, 1910
Dryer, Charles R., 1890, 1904a
Fuller, Myron L., 1914
Hollick, Charles A., 1899b
Kay, G. Marshall, 1953
Kindle, Edward M. (with Taylor, Frank B.), 1913
Leverett, Frank, 1902
Merrill, F. J. H., 1886b
Rich, John L., 1935
Stewart, David P., 1958
Stoller, James H., 1911, 1916, 1920
Tarr, Ralph S., 1905e
Williams, Henry S., and others, 1909
Woodworth, Jay B., 1901

74. Bibliography

Ellis, Mary, 1903

Geographic Index

EXPLANATORY NOTE

Each title in the foregoing bibliography is listed below under one or more geographic headings and is identified by author's name and date of publication. For complete reference data, refer to bibliographic listing.

The outlines of the geographic units employed in this index are indicated on figure 3, page 99. The units are physiographic and are adapted from the classifications of Fenneman and Cressey. The geographic units are as listed below. Each is identified on the bibliographic punch card layout (figure 1, page iv) by index code letter indicated at left:

- A. **The New England Upland** includes the Taconic Mountains, the Hudson Highlands and the relatively low-lying metamorphic terrane of southeastern New York. South of the Hudson Highlands it includes the Triassic basin with the Palisades of the Hudson developed on a diabase sill.
- B. **The Hudson-Champlain Lowland** is a north-south belt from the Canadian border to the Atlantic Ocean, separating the New England Uplands from the Adirondack Mountains and Appalachian Plateaus. In general, it is an area of low relief underlain by nonresistant sedimentary rocks. Strike ridges and valleys are developed along the beveled edges of folded strata west of the mid-Hudson Valley.
- C. **The Coastal Lowland** is an area of low relief that includes Fishers Island, Long Island, and part of Staten Island. Although largely underlain by marine sediments, the surface materials are extensively of glacial and fluvioglacial deposition.

- D. **The Mohawk-Black River Lowland** is a belt of low to moderate relief developed on nonresistant, relatively undeformed shales and limestones between the Adirondack Mountains and the Appalachian Plateaus. These low-lying areas channeled glacier flow and hence are rather intensively scoured and drift-covered.
- E. **The St. Lawrence Lowland** includes the area south of the St. Lawrence River, approximately to the limit of marine invasion and proglacial lake sediments flanking the crystalline rocks of the Adirondacks. It is an area of low relief in the north, but hilly in the south.
- F. **The Erie-Ontario Lowland** includes areas of low relief that border Lakes Erie and Ontario on the south. It extends south to the Onondaga limestone scarp and the strandlines of proglacial Lakes Whittlesey and Warren. It includes an extensive drumlin field.
- G. **The Adirondack Highland** comprises an area of moderate to high relief with maximum elevations more than 5,000 feet above sea level. The area is underlain by metamorphic and igneous rocks. It has been intensively glaciated and was the source of accumulation for small valley and cirque glaciers during waning of the continental ice sheet.
- H. **The Tug Hill Plateau** is an area of moderate relief, an outlier isolated from the Appalachian Plateau by the Mohawk lowland and a southeastward extension of the Ontario lowland. It is like other parts of the Appalachian Plateau Province in its undeformed bedrock structure, its moderate elevation and dissection, and in its glacial modification.
- I. **The Catskill Section of the Appalachian Plateaus** includes the highest elevations in southern New York. It is an area of moderate relief in the west and moderate to high relief in the east. Bedrock structure is essentially undeformed. The continental ice sheet covered even the highest summits.
- J. **The Southern New York Section of the Appalachian Plateaus** is an area of moderate relief, underlain by essentially undeformed Paleozoic rocks with low southward regional dip. The intensity of glacial erosion decreases southward. The Finger Lakes and associated through valleys are conspicuous products of glacial modification.
- K. **The Kanawha Section of the Appalachian Plateaus** differs from other parts of the province in New York, in that it escaped glaciation. The part of this section in New York lies chiefly south of the bend of the Allegheny River in southwestern New York.
- L. **New York.** This indicator refers to references which deal not with specific parts of the State, but with the State as a whole.

Physiographic Divisions of New York State

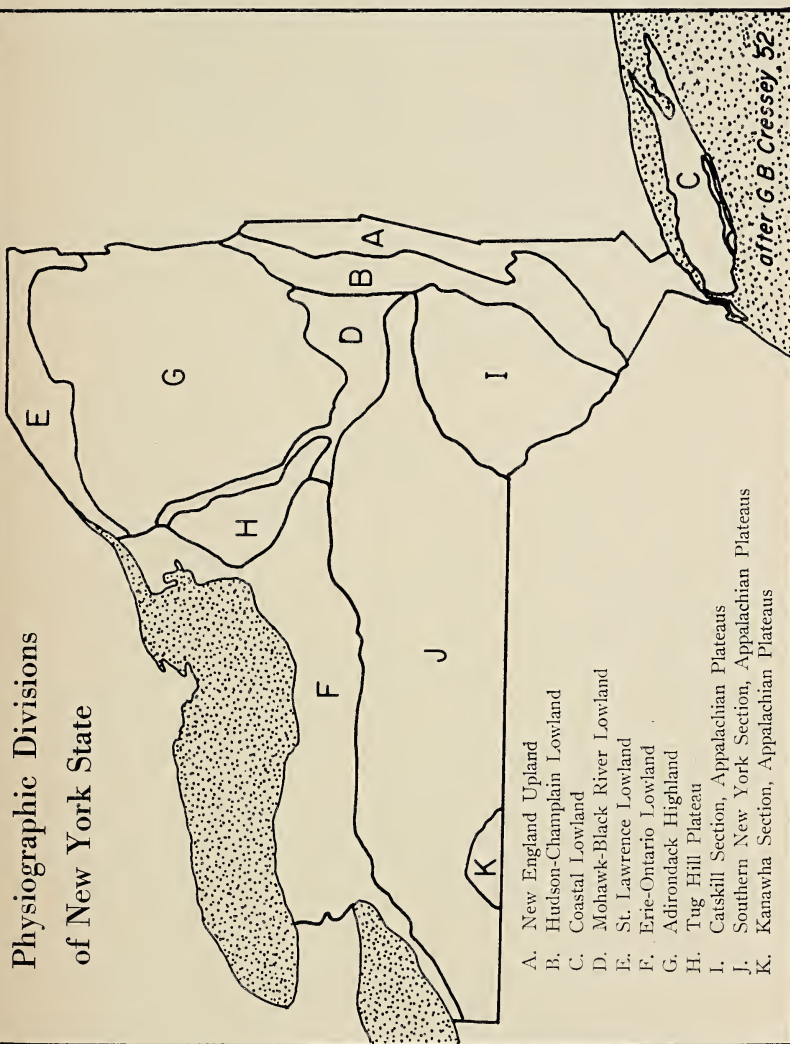


Fig. 3 Outline of physiographic units employed in geographic listing of titles

GEOGRAPHIC LISTING

A. New England Upland

- Benton, Edward R., 1878
Berkey, Charles P., 1906, 1911a, 1913
Berkey, Charles P. (with Hyde, Jesse E.), 1911b
Berkey, Charles P. (with Rice, Marion), 1921
Britton, Nathaniel L., 1881, 1882, 1886, 1887, 1888
Carlston, Charles W., 1946
Crosby, William O., 1914
Dekay, James E., 1824, 1829
Denny, Charles S., 1938
Edwards, Arthur M., 1892
Fitch, Asa, 1850
Fluhr, Thomas W., 1962
Gager, Charles S., 1932
Hobbs, William H., 1903, 1905a, 1905c
Hollick, Charles A., 1886, 1915, 1926
Humphreys, Edwin W., 1909
Humphreys, Edwin W. (with Julien, Alexis A.), 1911
Johnson, Douglas W., 1930, 1931b
Julien, Alexis A., 1906, 1910
Kemp, James F., 1896, 1897, 1907b, 1908, 1909, 1912
La Fleur, Robert G., and others, 1961
Lobeck, Armin K., 1918
Lowe, Kurt E., and others, 1958
Mackin, J. Hoover, 1933
Mather, William W., 1843
Merrill, F. J. H., 1890b, 1891, 1900
Merrill, F. J. H. (with Salisbury, Rollin D.), 1902
Miller, Sylvanus, 1836
Peet Charles E., 1894
Redfield, William C., 1842
Reed, Stephen, 1873
Reeds, Chester A., 1923, 1926, 1927, 1928
Salisbury, Rollin D. (with Darton, Nelson H.), 1908
Smith, Frances N., 1934
Stephens, Richard P., 1872
Stoller, James H., 1920
Taylor, Frank B., 1905, 1910b, 1910c
Thompson, Henry D., 1936a, 1936b, 1959
Tuttle, George W., 1904
Woodworth, Jay B., 1901
Worzel, John L. (with Drake, Charles L.), 1959
Wright, George F., 1905

B. Hudson-Champlain Lowland

- Antevs, Ernst, 1928
Baldwin, S. Prentiss, 1894

- Barker, Elmer E., 1913, 1916
Berdan, Jean M., 1954
Berkey, Charles P., 1911
Chadwick, George H., 1928d, 1928e
Chapman, Donald H., 1937, 1942
Clarke, John M., 1903a, 1907
Cook, John H., 1924, 1930, 1942, 1943, 1946a, 1946b
Cox, Donald D., 1959
Crosby, William O., 1914
Darton, Nelson H., 1894a, 1894b
Davis, William M., 1882, 1892, 1893
Desor, Edouard, 1850
Dwight, William B., 1866, 1885a, 1885b
Eaton, Amos, 1827
Eights, James, 1852
Elson, John A. (with Elson, Jeanne B.), 1959
Emmons, Ebenezer, 1842
Fairchild, Herman L., 1913a, 1914a, 1914b, 1916a, 1917a, 1919a
Fitch, Asa, 1850
Flint, Richard F., 1956
Gilbert, Grove K., 1871
Goldring, Winifred, 1922
Gordon, Clarence E., 1911
Gordon, Reginald, 1902a, 1902b
Hall, James, 1871
Happ, Stafford C., 1938a, 1938b
Hitchcock, Charles H., 1895
Holzwasser, Florrie, 1926
Hovey, Edmund O., 1908
Hubbard, Oliver P., 1889
Johnson, Douglas W., 1931b
Kellogg, D. S., 1892
La Fleur, Robert G., and others, 1961
Mackin, J. Hoover, 1933
Mather, William W., 1843
Merrill, F. J. H., 1890b, 1891
Miller, William J., 1911b
Newland, David H., 1909, 1916a, 1916b
Ogilvie, Ida H., 1902b
Osborn, Henry F., 1900
Peet, Charles E., 1904
Pyncheon, W. H. C., 1895
Ries, Heinrich, 1891, 1894
Shattuck, George B., 1907
Simpson, Eugene S., 1949, 1952
Stevens, Richard P., 1872
Stoller, James H., 1916, 1919a, 1919b, 1920, 1922a, 1922b, 1932
Taylor, Frank B., 1898a
Upham, Warren E., 1892a, 1892b, 1892c, 1903a
Woodworth, Jay B., 1905a
Wright, George F., 1895, 1898b, 1905

C. Coastal Lowland

- Alden, William C., 1918a, 1918b
Bailey, Paul, 1959
Brevoort, James C., 1859
Britton, Nathaniel L., 1881, 1884, 1887, 1888, 1889
Bryson, John, 1883, 1885, 1888a, 1888b, 1889, 1891a, 1891b,
1892, 1893a, 1893b, 1893c, 1894, 1895a, 1895b, 1896, 1897,
1898
Chamberlin, Thomas C., 1883
Charlier, Roger H., 1958
Cook, Edward H., 1857a, 1857b
Crosby, William O., 1900
Dana, James D., 1887, 1890
de Laguna, Wallace, 1949
de Laguna, Wallace (with Brashears, Maurice L., Jr.), 1946
Fairchild, Herman L., 1917b, 1917c
Fleming, W. L. S., 1935
Fox, Jay T., 1946
Fuller, Myron L., 1903b
Fuller, Myron L. (with Veatch, Arthur C.), 1903c
Gager, Charles S., 1932
Gratacap, Louis P., 1899, 1901
Hollick, Charles A., 1886, 1894, 1898, 1899a, 1899b, 1899c,
1900, 1901, 1908, 1915
Johnson, Douglas W., 1930
Kemp, James F., 1909
Kindle, Cecil H., 1946
Lewis, Elias Jr., 1868, 1873, 1877a, 1877b, 1877c
Lindenkohl, A., 1891
Lloyd, T. C. B., 1877a, 1877b, 1877c
Lobeck, Armin K., 1918
MacClintock, Paul (with Richards, Horace G.), 1936
Merrill, F. J. H., 1886a, 1886b, 1889, 1890a, 1890c, 1891, 1899-
Merrill, F. J. H. (with Salisbury, Rollin D.), 1902
Perlmutter, Nathaniel M., 1949
Redfield, William C., 1842, 1847
Richards, Horace G., 1956a, 1956b
Rosalsky, Maurice B., 1947, 1949, 1950
Spencer, Joseph W. W. 1904, 1905a, 1905b
Taney, Norman E., 1961
Tuttle, George W., 1904
Upham, Warren E., 1879
Upson, Joseph E., 1955
Veatch, Arthur C., 1903a, 1903b, 1906
Watson, Winslow C., 1859
Woodworth, Jay B., 1901

D. Mohawk-Black River Lowland

- Blume, Helmut, 1952
Brigham, Albert P., 1889, 1898a, 1898b, 1908, 1910, 1911,
1929, 1931

Coates, Donald R., 1959
Cook, John H., 1909, 1924, 1930, 1935
Cumings, Edgar R., 1899
Cushing, Henry P., 1905b
Cushing, Henry P. (with Ruedemann, Rudolph), 1914
Dana, James D., 1863
Darton, Nelson H., 1894a
Eaton, Amos, 1827
Eights, James, 1848
Emmons, Ebenezer, 1842
Fairchild, Herman L., 1904a, 1904e, 1909d, 1911b, 1912c
Hall, James, 1843b
Hanefeld, Horst, 1960
Kay, G. Marshall, 1953
Martens, James H. C., 1925
Megathlin, Gerrard R., 1938
Miller, William J., 1909a, 1909b, 1909c, 1910, 1919b
Roorbach, George B., 1913a, 1913b
Simpson, Eugene S., 1949, 1952
Smyth, Charles H., 1898a, 1898b
Stoller, James H., 1911, 1922a, 1922b, 1929, 1932
Taylor, Frank B., 1892
Tomlinson, C. H., 1832
Upham, Warren E., 1892b

E. St. Lawrence Lowland

Bendrat, T. A. 1908
Chalmers, Robert, 1895, 1896, 1904
Coleman, Arthur P., 1905
Cushing, Henry P., 1916
Cushing, Henry P., and others, 1910
Cushing, Henry P. (with Newland, David H.), 1925
Dreimanis, Aleksis, 1958, 1960
Elson, John A. (with Elson, Jeanne B.), 1959
Emmons, Ebenezer, 1842
Fairchild, Herman L., 1898a, 1898b, 1900a, 1907e, 1911a, 1919a, 1920
Finch, John, 1835
Flint, Richard F., 1956
Goldring, Winifred, 1922
Goldthwait, Joseph W., 1913, 1914
Johnson, Douglas W. 1925
Lloyd, T. C. B., 1875, 1876
MacClintock, Paul, 1954b, 1958
MacClintock, Paul (with Terasmae, Jaan), 1960
Martens, James H. C., 1925
Price, Charles A., 1954
Spencer, Joseph W. W., 1888b, 1890a, 1890b, 1890d, 1892b, 1900, 1913b, 1916, 1917
Stevens, Richard P., 1873
Stewart, David P., 1958

Stone, George H., 1891
 Taylor, Frank B., 1898a, 1924
 Terasmae, Jaan, 1959
 Upham, Warren E., 1895, 1896a, 1896b, 1903a
 Whittlesey, Charles L., 1867

F. Erie-Ontario Lowland

Baker, Manley B. (with Johnson, A. W.), 1924
 Bakewell, Robert, 1830, 1847, 1857
 Ballou, William H., 1882
 Belt, Thomas, 1875
 Bendrat, T. A., 1908
 Bishop, Irving P., 1897
 Chadwick, George H., 1917, 1923, 1931
 Chalmers, Robert, 1904
 Chamberlin, Thomas C., 1888
 Clarke, John M., 1903a
 Claypole, Edward W., 1877, 1879, 1882, 1886a, 1886b, 1889
 Coates, Donald R., 1959
 Coleman, Arthur P., 1899, 1917
 Connally, G. Gordon, 1960
 Cox, Donald D., 1959
 Darby, William, 1819
 Davis, William M., 1891b
 Davis, William M. (with Wood, J. W., Jr.), 1890
 Desor, Edouard, 1850b, 1850c, 1853, 1854
 Dewey, Chester, 1837, 1839, 1843a, 1843b
 Dreimanis, Aleksis, 1958
 Dryer, Charles R., 1890, 1908
 Eggleton, Frank E., 1931
 Fairchild, Herman L., 1894, 1895a, 1895b, 1895c, 1895d, 1895e, 1895f, 1896a, 1896b, 1896c, 1896d, 1897a, 1899a, 1900b, 1900c, 1900d, 1900e, 1900f, 1900g, 1901, 1902a, 1902b, 1902c, 1902d, 1903, 1904a, 1904b, 1904c, 1904d, 1904e, 1906a, 1906b, 1907a, 1907b, 1907c, 1907d, 1907e, 1909a, 1909c, 1911e, 1919b, 1920b, 1923, 1925a, 1926a, 1926d, 1928, 1929a, 1929b, 1930, 1932a, 1932b, 1932c, 1932d, 1932e, 1935a, 1935b
 Fairholme, George, 1834
 Featherstonhaugh, George W., 1831, 1845
 Finch, John, 1835
 Fleming, Mary A., 1899
 Foot, Lyman, 1822
 Forrester, Glenn C., 1926, 1928
 Gibbs, Lewis R., 1857a, 1857b
 Gilbert, Grove K., 1885, 1886a, 1886b, 1887, 1888a, 1888b, 1890, 1894, 1895, 1896a, 1896b, 1897b, 1898a, 1898b, 1899a, 1899b, 1899c, 1901a, 1901b, 1903, 1907, 1908
 Giles, A. W., 1918
 Goldthwait, Joseph W., 1910

- Grabau, Amadeus W., 1901a, 1901b, 1908b, 1909b, 1910, 1913a, 1918, 1920
Guernsey, J. A., 1831
Gunning, W. D., 1872
Hall, James, 1838, 1842, 1843a, 1843b, 1843c, 1843d, 1846, 1857
Hall, W. Carvel, 1907
Hallett, P. 1885
Hayes, George F., 1838
Heubusch, Carol A., 1958, 1959
Hitchcock, Charles H., 1901
Holley, George W., 1872, 1874
Holmes, Chauncey D., 1952, 1959
Hopkins, Thomas C., 1914
Hough, Jack L., 1958
Houghton, Frederick, 1914
Hyatt, Alpheus, 1869
Johnson, Laurence, 1882a, 1882b
Johnson, William A., 1928
Kindle, Edward M., 1921
Kindle, Edward M. (with Taylor, Frank B.), 1913
Kirk, Edwin, 1932
Letson, Elizabeth J., 1901
Leverett, Frank, 1892a, 1892b, 1895, 1898, 1902, 1939
Leverett, Frank (with Taylor, Frank B.), 1915
Lincoln, D. F., 1895b
MacClintock, Paul, 1952, 1954a
MacLean, William F., 1961
Marcou, Jules, 1865
Martin, J. O., 1901
Martin, Lawrence, 1915
Mather, Kirtley F., 1917
Mather, William W., 1841
Newberry, John S., 1874, 1882, 1889
Pohlman, Julius, 1883, 1886, 1889
Price, Charles A., 1954
Ramsey, Andrew C., 1858
Rogers, Brownell, 1893
Rogers, Henry D., 1835
Scovell, Josiah T., 1889, 1891
Shaler, Nathaniel S., 1893
Shepard, Francis P., 1937
Sissons, J. B., 1960
Slater, George, 1928, 1929
Smith, Burnett, 1914, 1929
Spencer, Joseph W. W., 1881, 1882, 1883, 1887a, 1887b, 1888a, 1888b, 1889, 1890a, 1890b, 1890c, 1890d, 1890e, 1890f, 1891a, 1891b, 1891c, 1892b, 1894a, 1894b, 1894c, 1894d, 1894e, 1895, 1896, 1898a, 1898b, 1898c, 1898d, 1898e, 1907a, 1907b, 1907c, 1908a, 1908b, 1908c, 1908d, 1908e, 1908f, 1908g, 1908h, 1910a, 1910b, 1910c, 1910d, 1910e, 1913a, 1913b, 1913c, 1913d, 1914a, 1914b, 1915, 1921

Stewart, David P., 1958
Stone, George H., 1891
Tarr, Ralph S., 1894, 1896a
Taylor, Frank B., 1895, 1897a, 1898a, 1898b, 1898c, 1907,
1910a, 1912, 1913a, 1913b, 1913c, 1914, 1925a, 1925c, 1927a,
1927b, 1927c, 1929, 1930, 1931a, 1931b, 1932, 1939
Thomas, David, 1830
Tyndall, John, 1873
Upham, Warren E., 1890, 1892c, 1893, 1894, 1895, 1896a,
1896b, 1898a, 1898b, 1901, 1903b, 1905, 1908
Vanuxem, Lardner, 1842
Whittlesey, Charles L., 1850, 1866
Wilson, A. W. G., 1908a, 1908b
Winchell, Alexander N., 1897
Woodward, Robert S., 1886a, 1886b
Wright, George F., 1884a, 1884b, 1890, 1898a, 1899a, 1899b,
1921

G. Adirondack Highland

Alling, Harold L., 1916, 1919a, 1919b, 1921
Balk, Robert, 1932
Bendrat, T. A., 1908
Brigham, Albert P., 1898
Chadwick, George H., 1928a, 1928b
Cook, John H., 1924
Crowl, George H., 1950
Cushing, Henry P., 1901, 1905a, 1905b, 1907, 1918
Cushing, Henry P. (with Newland, David H.), 1925
Dale, Nelson C., 1935a
Davis, William M., 1906
Dreimanis, Aleksis, 1960
Emmons, Ebenezer, 1842
Fairchild, Herman L., 1907e, 1911a, 1911b, 1920a
Fitch, Asa, 1850
Gordon, Clarence E., 1941
Johnson, Douglas W., 1917a, 1917b
Kay, G. Marshall, 1953
Kellogg, D. S., 1892
Kemp, James F., 1901, 1905, 1906, 1907a, 1910
Kemp, James F. (with Alling, Harold L.), 1925
Lloyd, T. C. B., 1875, 1876
MacClintock, Paul, 1958
MacClintock, Paul (with Terasmae, Jaan), 1960
Martens, James H. C., 1925
Miller, William J., 1909a, 1909b, 1909c, 1910, 1911a, 1911b,
1914, 1915, 1916, 1917a, 1917b, 1919a, 1920, 1921, 1925a,
1925b, 1926
Ogilvie, Ida H., 1902a, 1902b
Redfield, William C., 1838
Ries, Heinrich, 1894a

- Ruedemann, Rudolph, 1931
Smyth, Charles H., 1893
Spencer, Joseph W. W., 1890b, 1890d, 1892b, 1912a, 1912b
Stevens, Richard P., 1873
Stoller, James H., 1916, 1930
Taylor, Frank B., 1897, 1924
Upham, Warren E., 1889, 1920
Whitnall, Harold O., 1945
Willcox, Joseph, 1873, 1884
Woodworth, Jay B., 1905b, 1907
Wright, George F., 1895

H. Tug Hill Plateau

- Bendrat, T. A., 1908
Brigham, Albert P., 1889, 1892
Hall, James, 1843
Hanefeld, Horst, 1960
Miller, William J., 1909b
Stewart, David P., 1958

I. Catskill Section of the Appalachian Plateaus

- Berdan, Jean M., 1954
Berkey, Charles P., 1911
Chadwick, George H., 1910, 1916, 1928, 1933
Coates, Donald R., 1959
Cook, John H., 1924, 1935, 1946a
Cressey, George B., 1935
Darton, Nelson H., 1894a, 1894b, 1896, 1914
Friedman, Jules D., 1957
Hall, James, 1843b
Heusser, E., 1939
Johnson, Douglas W., 1917a, 1917b
Julien, Alexis A., 1881, 1885
Lobeck, Armin K., 1918
Myers, Richmond E., 1946
Niles, William H., 1894
Ramsay, Andrew C., 1858
Rich, John L., 1906, 1914, 1915b, 1917, 1918, 1935
Ruedemann, Rudolph, 1932
Smock, John C., 1880, 1885

J. Southern New York Section of the Appalachian Plateaus

- Alden, William C. (with Fuller, Myron L.), 1903a, 1903b
Apfel, Earl T., 1932a, 1932b, 1946
Apfel, Earl T. (with Holmes, Chauncey D.), 1931
Bishop, Irving P., 1897
Brigham, Albert P., 1889, 1892, 1893, 1895, 1896, 1897, 1915
Brown, Clair A., 1956
Bryan, Kirk, and others, 1935
Burroughs, Wilbur G., 1933

- Campbell, Marius E., 1903a, 1903b, 1904
Carll, John F., 1880
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Chadwick, George H., 1931, 1935
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- Holmes, Chauncey D., 1935a, 1935b, 1937, 1938, 1941, 1944a, 1944b, 1946, 1947, 1952, 1958, 1959, 1960
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Koenig, Martin (with Lumbard, Paul A.), 1937
Leverett, Frank, 1892a, 1892b, 1895, 1898, 1902, 1939
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Appendix I

GRADUATE THESES ON NEW YORK QUATERNARY GEOLOGY

The following list of titles of graduate theses on problems of New York Quaternary geology is appended in recognition of the fact that a large body of pertinent and valuable research data lies often untapped in unpublished dissertation form. The list is neither indexed nor verified. Time limitation, variability of thesis quality, and the scattered distribution of manuscripts have made it impractical to examine more than a few of the papers listed. Undergraduate theses and research papers are not listed, for it is commonly very difficult to track down such manuscripts. Graduate theses, on the other hand, are generally on file in the library system of the degree-granting university. Most current doctoral dissertations are now available on microfilm at a reasonable price from University Microfilm Service, Ann Arbor, Mich.

- Adams, George F.** 1934. Glacial waters in the Wallkill Valley. Master's thesis. Columbia University
- Alling, Harold L.** 1917. Glacial lakes and other glacial features of the central Adirondacks. Master's thesis, Columbia University
- Alling, M. K.** 1924. A study of the physiographic history of Allen's Creek at Corbett's Glen. Master's thesis. The University of Rochester
- Baker, Elizabeth.** 1930. Tentative evaluation of some of the factors influencing topographic development in central New York State. Master's thesis. Cornell University
- Blackmon, Paul.** 1956. Glacial geology of the East Aurora, New York, quadrangle. Master's thesis. The University of Buffalo (now State University of New York at Buffalo)
- Blagbrough, John.** 1951. The red clay deposits of Otisco Valley. Master's thesis. Syracuse University

- Brainerd, A. E. & Perry, C. W.** 1912. Pleistocene deposits of a section of the larger Cicero Swamp. Master's thesis. Syracuse University
- Brainerd, W. F.** 1922. Dana glacial lake terrace and the great delta of Onondaga Valley. Master's thesis. Syracuse University
- Bryant, Jay C.** 1955. A refinement of the upland glacial drift border in southern Cattaraugus County, New York. Master's thesis. Cornell University
- Carlston, Charles W.** 1946. Appalachian drainage and the Highland Border sediments of the Newark series. Ph. D. thesis. Columbia University
- Carney, Frank.** 1909. Pleistocene geology of the Moravia quadrangle, New York. Ph. D. thesis. Cornell University
- Case, Ermine C.** 1895. The drumlin region of western New York together with some experiments on ice action. Master's thesis. Cornell University
- Chisnell, Thomas C.** 1941. A correlation test of Knickpunkte. Master's thesis. Cornell University
- Chisnell, Thomas C.** 1951. Recognition and interpretation of proglacial strand lines in the Cayuga Basin. Ph.D. thesis. Cornell University
- Connally, G. Gordon.** 1959. Heavy minerals in the glacial drift of western New York. Master's thesis. The University of Rochester
- Cornish, C. B.** 1929. The geography and history of Cortland County. Master's thesis. Cornell University
- Cox, Donald D.** 1958. Some postglacial forests in central and eastern New York State as detected by the method of pollen analysis. Ph.D. thesis. Syracuse University
- Crowl, George H.** 1950. Erosion surfaces in the Adirondacks. Ph.D. thesis. Princeton University
- Cuthbert, F. L.** 1937. A geologic study of Cattaraugus Creek and vicinity with special reference to Pleistocene sediments. Master's thesis. The University of Buffalo (now State University of New York at Buffalo)
- D'Agostino, John.** 1957. Glacial Lake Tonawanda, history and development. Master's thesis. The University of Buffalo (now State University of New York at Buffalo)
- Davis, Ethel.** 1941. Glacial geology of the Palmyra and Pultneyville quadrangles, New York. Master's thesis. The University of Rochester
- Dollen, Bernard.** 1931. Preglacial drainage of the northeastern United States. Master's thesis. The University of Rochester
- Dunbar, E. U.** 1923. Glacial Lake Succession in the Genesee Valley. Master's thesis. The University of Rochester
- Durham, Forrest.** 1954. The geomorphology of the Tioughnioga River of central New York. Ph.D. thesis. Syracuse University
- Edwards, Ira.** 1914. Pleistocene geology of the Albion-Holly district. Master's thesis. The University of Rochester

- Eldredge, F. E.** 1911. Surficial geology of the vicinity of Syracuse. Master's thesis. Syracuse University
- Elston, E. D.** 1915. Some factors influencing the initiation and development of normal potholes. Master's thesis. Cornell University
- Faltyn, Norbert E.** 1957. Seismic exploration of the Tully Valley overburden. Master's thesis. Syracuse University
- Filmer, E. A.** 1928. The glacial geology of the Binghamton, New York, quadrangle. Master's thesis. Cornell University
- Fleming, W. L.** 1931. Glacial geology of central Long Island. Master's thesis. Yale University
- Foote, Charles W.** 1877. Notes upon the geological history of Cayuga and Seneca Lakes, together with a few general remarks upon the glacial period. Ph.D. thesis. Cornell University
- Forde, Margaret E.** 1934. Summary of the geologic literature of the Tarrytown quadrangle, N.Y. Master's thesis. Columbia University
- Fridley, Harry M.** 1928. Identification of erosion surfaces in south-central New York. Ph.D. thesis. Cornell University
- Gabriel, Ralph H.** 1919. The evolution of Long Island: a story of land and sea. Ph.D. thesis. Yale University
- Gifford, John D.** 1941. Glacial drainage in the Kasoag quadrangle, New York, as indicated by eskers. Master's thesis. University of Oklahoma
- Giles, A. W.** 1910. Eskers of western New York. Master's thesis. The University of Rochester
- Goldich, Samuel S.** 1930. The mechanical composition of the till in the Syracuse region. Master's thesis. Syracuse University
- Happ, Stafford C.** 1938. Geomorphic problems in the Minisink Valley. Ph.D. thesis. Columbia University
- Hasser, Edward G.** 1954. A study of Lake Iroquois and post-Lake Iroquois sediments in a peat bog. Master's thesis. Syracuse University
- Holmes, Chauncey D.** 1927. Special glacial features of the Cazenovia quadrangle. Master's thesis. Syracuse University
- Holmes, Chauncey D.** 1939. Pleistocene geology of the region south of Syracuse, New York. Ph.D. thesis. Yale University
- Huck, Florence.** 1920. Comparative lithological study of the materials found in the drift of the Syracuse region. Master's thesis. Syracuse University
- James, Carolyn.** 1943. A boundary between the Hudson Valley and New England Provinces drawn from geomorphic differences. Master's thesis. Columbia University
- Johnson, Howard F.** 1933. The upland erosional surfaces of the Catskills in relation to the present-day drainage. Master's thesis. Cornell University

- Kaiser, Russell F.** 1939. The composition and origin of the glacial till in the Mexico and Kasoag quadrangles, N.Y. Master's thesis. Syracuse University
- Kaiser, Russell F.** 1957. The surficial geology of the southeastern segment of the Lake Ontario till plain, New York. Ph.D. thesis. Syracuse University
- King, Jessie M.** 1934. Glacial sculpture in the region of the north-flowing Finger Lakes of central New York. Master's thesis. Columbia University
- Knight, Pauline U.** 1933. Former drainage of the northern Appalachians. Master's thesis. Columbia University
- Koch, G. H.** 1932. The hydrology of the Onondaga drainage basin. Master's thesis. Syracuse University
- Langey, E. J.** 1952. Unconsolidated sediments in the Black River area of New York State. Ph.D. thesis. Syracuse University
- Leroy, F. L.** 1938. Outlet history of preglacial Cayuga Lake. Master's thesis. Cornell University
- Lockheed, William.** 1895. Preglacial drainage of the Upper Cayuga Basin. Master's thesis. Cornell University
- Marks, Milton.** 1954. Petrology of some sand and gravel deposits near Syracuse, New York. Master's thesis. Syracuse University
- Martin, J. O.** 1903. A study of the drumlin area of New York State. Master's thesis. Cornell University
- Matson, George C.** 1903. A contribution to the study of the interglacial gorge problem. Master's thesis. Cornell University
- Merritt, Richard S.** 1958. Depth of leaching in relation to carbonate content of glacial till in central New York. Master's thesis. Cornell University
- Miller, D. W.** 1953. Potential ground water storage capacity of the upper Pleistocene deposits in Kings County, N.Y. Master's thesis. Columbia University
- Miner, Neil A.** 1933. The origin and history of Green and Round Lakes in Green Lake State Park at Fayetteville, New York. Master's thesis. Syracuse University
- Monnett, Victor E.** 1922. The glacial physiography of the Skaneateles basin. Ph.D. thesis. Cornell University
- Myers, Paul E.** 1958. A petrographic and statistical study of the crystalline constituents of central New York glacial deposits. Master's thesis. Syracuse University
- Namowitz, Samuel N.** 1937. The great inland scarp of Long Island. Master's thesis. Columbia University
- Neel, Robert.** 1951. Stratigraphy and glacial geology of the Portage quadrangle, New York. Master's thesis. The University of Rochester
- Newell, J. G.** 1940. The geomorphic development of the Tug Hill Plateau. Master's thesis. Syracuse University

- Oberlander, Theodore M.** 1956. Glacial and drainage patterns in the Limestone Creek watershed. Master's thesis. Syracuse University
- O'Connell, D. T.** 1926. Pleistocene ice movement in New York City. Master's thesis. New York University
- O'Connell, D. T.** 1932. Review of geology of the eastern part of Bronx County, New York. Ph.D. thesis. New York University
- Peltier, Louis C.** 1939. The glacial geology of Lower Clove Creek Valley, New York. Master's thesis. Columbia University
- Perry, C. W.** 1912. Pleistocene deposits of a section of the larger Cicero Swamp. Master's thesis. Syracuse University
- Phillips, C. W.** 1912. Subsidence structure in Onondaga County. Master's thesis. Syracuse University
- Poth, Charles W.** 1953. A study of the Pleistocene sediments and glacial geology in the valley of Ischua Creek (New York). Master's thesis. The University of Buffalo (now State University of New York at Buffalo)
- Reinecke, Leopold.** 1909. A contribution to the petrography of the Ithaca Drift. Master's thesis. Cornell University
- Rice, H. J.** 1881. Physiography of Cazenovia Valley. Ph.D. thesis. Syracuse University
- Rich, John L.** 1907. Types of marginal glacial drainage in the Finger Lake region. Master's thesis. Cornell University
- Rockwell, Charles.** 1957. A mineral analysis of the sediments of the south shore of Long Island. Master's thesis. University of Oklahoma
- Rudell, Marjorie.** 1935. Glacial gravels, Manhasset formation of Long Island as found in the pits of Goodwyn Gallagher, Roslyn, New York. Master's thesis. Columbia University
- Schmidt, Victor E.** 1947. Varves in the Finger Lakes region of New York. Ph.D. thesis. Cornell University
- Shumaker, Robert C.** 1957. Till texture variation and Pleistocene deposits of the Union Springs and Scipio quadrangles, Cayuga County, New York. Master's thesis. Cornell University
- Shupack, Benjamin.** 1932. Some foraminifera from Long Island and New York harbor. Master's thesis. Columbia University
- Shupack, Dora.** 1939. Foraminifera of the Lincoln Tunnel. Master's thesis. Columbia University
- Simpson, Eugene S.** 1945. Buried pre-glacial channels in the Albany-Schenectady area in New York. Master's thesis. Columbia University
- Smith, Virginia H.** 1938. A review of peneplane interpretations in the Appalachian Plateau. Master's thesis. Columbia University
- Stewart, David P.** 1954. The surface geology and Pleistocene history of the Watertown and Sackets Harbor quadrangles, N.Y. Ph.D. thesis. Syracuse University

- Suess, I. L.** 1932. Problem of post-glacial differential uplift. Master's thesis. The University of Rochester
- Sweet, Lois B.** 1934. Rock gorges associated with the outlet of Cayuga Lake. Master's thesis. Cornell University
- Thompson, Henry D.** 1936. Hudson Gorge in the Highlands. Ph.D. thesis. New York University
- Threet, Richard L.** 1949. Geology and the origin of the Lake Ontario basin. Master's thesis. University of Illinois
- Tuttle, Frances.** 1943. Textural and mineralogical analysis of late Wisconsin glacial and post-glacial deposits from Suffolk County, New York. Master's thesis. Smith College
- Walters, R. F.** 1938. Glacial geology of Monroe County, New York. Master's thesis. The University of Rochester
- Watson, T. L.** 1897. Some higher levels in the post-glacial development of the Finger Lakes of New York State. Ph.D. thesis. Cornell University
- Weiss, Lawrence.** 1951. Origin of the Pleistocene Gardiners clay in eastern Long Island. Master's thesis. New York University
- Whiteman, Edith.** 1930. Regional physiography of the Capital District of New York State. Albany, Cohoes, Troy, and Schenectady quadrangles. Master's thesis. Columbia University
- Wilbur, Doris M.** 1931. The Pleistocene and recent history of the Randolph, New York, area. Ph.D. thesis. University of Iowa
- Wintringham, N. A.** 1947. The geology of Dutchess County, New York. Master's thesis. Cornell University
- Wold, J. S.** 1939. Interglacial consequents of central New York. Master's thesis. Cornell University

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The Culicoides of New York State (Diptera: Ceratopogonidae)

by

Hugo Jamnback

Senior Scientist

New York State Museum and Science Service

BULLETIN NUMBER 399

NEW YORK STATE MUSEUM
AND SCIENCE SERVICE

*The University
of the State
of New York*

ALBANY, NEW YORK

*The State
Education
Department*



JULY, 1965



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FRONTISPIECE. Head of female *Culicoides variipennis*

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The Culicoides of New York State (Diptera: Ceratopogonidae)

by Hugo Jamnback

ABSTRACT

DESCRIPTIONS OF THE MALES, females, and known pupae and larvae of *Culicoides* recorded from New York State are given, together with notes on their geographic and seasonal distribution, breeding sites, and feeding habits. Keys to the mature and immature stages, where known, are included. Of the 37 species collected in the State, 2 were previously undescribed and 14 others are recorded here for the first time.

Introduction

Culicoides THAT ATTACK MAN in search of a blood meal are locally called "punkies," "no-see-ums," "gnats," or "biting midges" in the forested regions of the State, while along the coast they are usually called "sand flies"; in French Canada they are called "brûlots."

The bite of *Culicoides* is characterized by a slight initial burning sensation. Pechuman (unpublished notes²) believes that the common names "punkie" and "brûlot" are based on this characteristic effect of their bite. The Algonquin Indian language has a root "punkw" which relates to anything ash-like or powder-like. Words derived from this root take several forms in the various Algonquin dialects of which the Delaware (Lenape) is one (Hodge, 1910).

Loskiel (1794, part III, p. 79) shows that "ponk" was still in use by the Delawares at a rather late date. The following quotation is from his report on the migration of the Christian Delawares from eastern to western Pennsylvania.

"The most troublesome plague to both man and beast, especially in passing through the woods, was a kind of insect called by the Indians, Ponk, or *Living Ashes*, from their being so small that they are hardly visible, and their bite as painful as the burning of red-hot ashes."

The Delaware word "ponk" (also spelled "punk" and "punkus,") appears to have been taken over by the Dutch in New Amsterdam. The Dutch called *Culicoides* "punkie" (plural "punken"); and when the English took over New Amsterdam and changed its name to New York, they also apparently took over "punkie," spelling it "punkie" or "punky."

² The discussion on the derivation of common names is based on these notes and is given here with the kind permission of Dr. L. L. Pechuman, Department of Entomology, Cornell University.

The name brûlot probably is derived from the French verb "bruler" meaning to burn. LaHontan (1703, Vol. 1, p. 242) states "The brûlots are a sort of Hand-worms, which cleave so hard to the Skin, that their pricking occasions the same sense, as if 'twere a burning Coal, or a spark of Fire. These little Animals are unperceivable, though at the same time pretty numerous."

Except in moist habitats, protected from the wind, *Culicoides* are rarely in evidence during the day but they may become extremely annoying beginning shortly before sunset and often continue biting into the night and early morning. Since they are attracted to light and are small enough to pass through window screens, they may become pests indoors during the evening.

Of the 37 species so far recorded from the State, 17 have been recorded feeding on man. Of these, only five are abundant and annoying enough to be considered pests. Most of the species are inconspicuous and, although they may occur in enormous numbers, are rarely observed. Many are primarily ornithophilic, while others prefer the blood of mammals other than man. Still others have reduced, or poorly developed mouthparts, and are not capable of taking a blood meal.

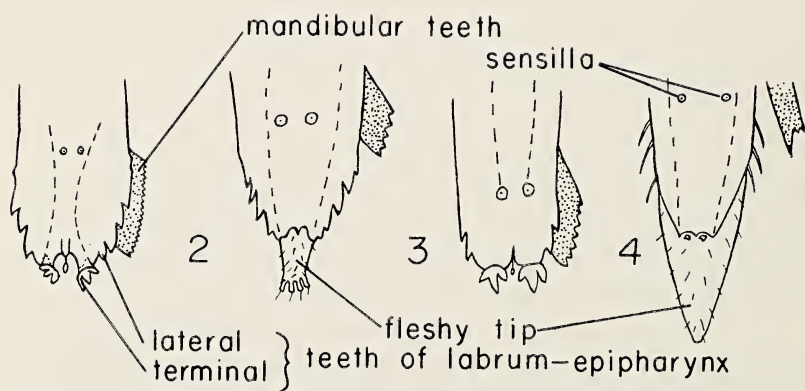
In recent years, the role of *Culicoides* as possible vectors of disease producing organisms has received increasing attention. They have been incriminated as vectors of viruses (blue-tongue of sheep and eastern encephalitis), protozoa (*Haemoproteus* spp. and a *Leucocytozoon* species) and numerous filarial nematodes parasitic on man and the larger mammals, both domestic and wild (see review by Fallis & Bennett, 1961a). However, studies along these lines have been hindered by the difficulty in accurately identifying the suspected vectors, by a lack of information on feeding preferences, and by difficulties in maintaining most of the species in the laboratory. Our knowledge of *Culicoides* taxonomy has advanced considerably in recent years, so much so that twenty-one of the 37 species known to occur in New York State have been described, redefined, or resurrected from synonymy since 1954. This paper brings together both published and unpublished information which should facilitate the identification of New York State species, and it summarizes knowledge of their distribution and habits.

The assistance of the following persons and organizations is acknowledged: W. W. Wirth, Entomology Research Branch, U.S.D.A., without whose cooperation, collections, records, identifications, and encouragement this study could not have been completed; C. O. Berg, Cornell University; R. Means, University of Massachusetts;

R. Jones, Entomology Research Branch, U.S.D.A.; E. Warner, St. Lawrence University; and personnel of the Suffolk County Mosquito Control Commission for collections of *Culicoides*. To the Adirondack Museum and the donors to the Adirondack Entomology Research Fund, for quarters and financial assistance during four seasons of study in the Adirondacks; to the New York State Conservation Department, who aided the Statewide survey by providing temporary quarters in State parks, and to D. L. Collins, State Entomologist and Principal Scientist, Biological Survey, New York State Museum and Science Service, under whose overall direction this work was carried out.

Collections by W. W. Wirth and the author are indicated by the initials WWW and HAJ, respectively. Collections by other workers are cited using their last names and initials.

Photographs of most of the *Culicoides* wings were prepared by Sally Craig of the Medical Audio-Visual Department, Walter Reed Army Institute of Research, Washington 12, D. C. Figures 18, 23 and 185 were redrawn from sources acknowledged in the text; the rest are original photographs or drawings by the author.



TEXT FIGURES 1-4. Details of mouth parts

Bionomics

THE LIFE HISTORIES OF MOST *Culicoides* follow a rather similar pattern (see reviews by Downes, 1958; Kettle, 1962). Although breeding may continue around the year in the tropics, *Culicoides* in temperate regions normally overwinter as larvae (although there is evidence suggesting that some overwinter as eggs, p. 102). Some species appear in the early spring in large numbers, which decline by midsummer, and increase again in the late summer or early autumn, suggesting two generations per year (e.g., *crepuscularis* and *hollensis*); others reach peak abundance in the spring or early summer followed by a gradually dwindling in numbers (most of the *piliferus* gp., *sanguisuga*); or reach peak abundance in midsummer (*melleus*); while still others are present in more or less uniform numbers over long periods (*biguttatus*), suggesting multiple generations or an extended emergence period. In some instances the female does not require a blood meal for the first oviposition (Downes, 1958; Jamnback, 1961). Although females of most species have well developed mandibular teeth and a moderate to long proboscis (see frontispiece and text-figure 1) some have weak mouthparts and are incapable of taking a blood meal.

There are two types of mouthparts not adapted for bloodsucking. (Text-figures 1-4. Mandible and tip of labrum-epipharynx. (1) *C. varipennis* female; (2) *C. denticulatus* female; (3) *C. flukeyi* female; (4) *C. crepuscularis* male.) Both are characterized by a short proboscis and reduced mandibular dentition. In one type there is a fleshy distal conical prolongation at the tip of the labrum-epipharynx and the tormae are weak (text-figure 2). These structures closely resemble those of the non-bloodsucking males (text-figure 4), including those species in which the female is haematophagus. Whether these represent a primitive non-bloodsucking condition, or are secondarily reduced from a more primitive blood-sucking pre-

cursor (Downes, 1958b) and convergently resemble the male, is a matter for conjecture. Included species are: *denticulatus* (6)³, *dickei* (4), *loisae* (6), and *utowana* (6). The second type lacks the fleshy prolongation of the labrum-epipharynx, suggesting that the female is non-haematophagus or borderline haematophagus due to a reduction in mouthparts (text-figure 3). Species of this type include *bermudensis* (3-5), *flukeyi* (6), *furenoides* (4), and *wisconsinensis* (4).

Although host preferences of *Culicoides* are not well known, it would appear that the antennae of ornithophilic species have more olfactory pits (see Dethier, 1954, for discussion of evidence regarding the olfactory function of these sensilla) than those that favor large mammals (including man) as the source of a blood meal; a not unreasonable adaptation when the relative size and probable amount of odor produced by large mammals and small birds is considered. This difference is illustrated in table 1, where the number of antennomeres (Snodgrass, 1935, considers the flagellum to be a single subdivided segment) with olfactory pits of known ornithophilic and mammalophilic species are compared.

TABLE 1. The correlation between abundance of sensory pits on antennal segments and known host preferences of *Culicoides*

Primarily ornithophilic species	No. of segments with olfactory pits	Primarily mammalophilic species*	No. of segments with olfactory pits
<i>crepuscularis</i>	13	<i>furens</i>	4
<i>downesi</i>	9	<i>hollensis</i>	4
<i>haematopotus</i>	12	<i>melleus</i>	6
<i>scanloni</i>	10	<i>obsolctus</i>	6
<i>sphagnumensis</i>	13	<i>sanguisuga</i>	6
<i>stilobezzioides</i>	8	<i>variipennis</i>	4

* Large mammals.

Using the number of antennomeres with olfactory pits as a criterion, the following species, whose host preferences is largely unknown, would be expected to be ornithophilic: *niger* (13), *travisi* (13), *arboricola* (9), *guttipennis* (9), *piliferus* (9), *villosipennis* (9), *baueri* (8), *biguttatus* (8) and *pseudopiliferus* (8). In contrast, *bickleiyi* (4), *stellifer* (4), *chiopterus* (6), *jamnbacki* (6), *spinus* (6) and *venustus* (6) would be expected to prefer large mammals. *Testudinalis* (7) is unique in feeding on reptiles. There is one record of another intermediate species, *alexanderi* (7), feeding on man.

³ Number of antennomeres with olfactory pits.

In *sanguisuga*, and probably other species, a blood meal is required for egg development after the first ovarian cycle which may be autogenous. This blood meal does not contribute to longevity, although sugar solutions do (Jamnback, 1961), suggesting that haematophagous species may also visit flowering plants to feed on nectar (Downes, 1958b). Along these lines, it might be noted that Posnette (1944) and Warmke (1951, 1952) found that *Culicoides* were important pollinators of cacao and rubber trees, respectively.

Some species form mating swarms while others do not, and some mate before seeking a blood meal while others do not. Dissections of wild *sanguisuga* females landing and biting man indicate that most mate before seeking a blood meal. An exception, *bermudensis*, is both autogenous and parthenogenetic (Williams, 1961). The sex ratio of most species that have been studied is close to 1:1, although light traps usually contain a preponderance of females. Typically, the oöcytes develop rapidly, and eggs are laid within a week or ten days after the females emerge, if autogenous; or about the same length of time after a blood meal, if not. The eggs cannot resist prolonged drying and are laid on a moist substrate. The females of some species live for well over a month and lay several batches of eggs. The eggs hatch in a few days, and the first instar larvae emerge. Many, probably all, species possess a functional spine-bearing proleg in the first instar but later instars lack prolegs.

The larval habitats of some species are rather specific and easily described. The major types were classified by Mayer (1934). Jones (1961a) described the breeding habitats of a number of North American species including 14 that are recorded from New York State. The treehole breeders, *arboricola*, *flukeyi*, *guttipennis*, and *villosipennis*; the intertidal sand breeder *melleus*; to a lesser extent, the salt marsh breeders *bermudensis*, *furens*, and *hollensis* fall into this category. *Sanguisuga*, which breeds in leaf accumulations on well-drained sites; *chiopterus*, which breeds in animal feces, or materials such as hay, mud, or humus, contaminated with animal droppings, are other examples. However, many species breed in a generalized habitat which includes the margins of lake, ponds, streams, springs, swamps, marshes, and pools. The main characteristic in common with all of these sites is that they are moist at the time when the *Culicoides* female lays her eggs. During the oviposition period, for many species in mid- or late-summer, there are relatively few moist sites.

In the spring, during the high water period, many of these sites are flooded and the larvae are submerged for long periods, ranging

from several weeks to months. Collections made at this time indicate that the larvae are present both above and below the waterline, often in sites which are covered by water for long periods. Later collections, made after the water level has receded, are most productive at the waterline. It seems likely that the larvae follow the moisture as the waterline recedes. Each micro-environment, i.e., swamp, marsh, stream margin, pool, etc., contains a multitude of micro-environments or substrates, such as bare mud or sand, mud with varying amounts of vegetation, sphagnum, decaying leaves, and combinations of these. Some species in the generalized habitat may be limited to specific types of microhabitats, but my studies were not sufficiently detailed to demonstrate this.

COLLECTION AND PREPARATION OF SPECIMENS

Many species of *Culicoides* can be collected in large numbers in light traps, and this method was used commonly. Additional adults were reared from larvae and pupae collected in the field, and others collected while attacking man and animals.

Several techniques were employed to collect the immature stages. The most common method involved sieving and flotation with magnesium sulphate, as outlined by Kettle & Lawson (1952). Suspected samples of breeding media were washed with running water through 10, 20, and 80 mesh sieves. The larvae passed through the first two and were retained by the last sieve, along with fine detritus. This material was placed in a wide-mouthed, low, glass jar and a saturated aqueous solution of magnesium sulphate added. After stirring, the *Culicoides* larvae and pupae floated to the surface together with some material of plant origin. The *Culicoides* were picked out with "minuten nadeln" imbedded in glass rods and transferred to fresh water. Brief exposure to magnesium sulphate was not injurious, and it was possible to rear the larvae and pupae collected in this manner. When collecting only pupae, the suspected breeding media was placed in a container and covered with water. The pupae soon came to the surface where they could be collected with a medicine dropper (except for *obsoletus* group species which remained submerged).

Berlese funnels were also used to dry samples of suspected breeding media. The larvae and pupae migrated downward as the surface dried and were collected in a jar of water beneath the funnel. Al-

though there was some mortality due to larvae drying out while crawling down the sides of the funnel, large numbers of larvae and pupae were collected in this way.

Occasionally, methods can be devised for rapidly sampling larval and pupal populations occurring in unusual habitats. Those occurring in treeholes can readily be collected by siphoning the water into a jar. The coastal species, *C. melleus*, breeds in clean intertidal sand. Larval populations could quickly be assessed by shaking a sample of the sand in an equal volume of fresh water, decanting off the water and examining it (Jamnback & Wall, 1958).

Larvae or pupae kept for rearing were placed, individually, into separate 4-dram vials on a piece of moist cotton. The tops of the vials were stoppered with cotton. These were examined daily and moisture added as required.

All stages were normally preserved in 70-80 percent ethyl alcohol. When slide mounts were prepared for microscopic examination, phenol was used as a clearing medium. Specimens cleared in phenol retain their natural pigmentation unlike those cleared in KOH. Phenol crystals were dissolved in diaphane solvent (with cellosolve added) or in absolute alcohol rather than water, so that the specimens could be mounted directly in diaphane or balsam without intermediate dehydration. Specimens were transferred directly from alcohol into the clearing medium and left overnight, or for several days, without deterioration or excessive clearing. Females were placed on slides with the head and wings detached from the thorax and covered with a small (12 mm.) cover slip. For the males, the wings, head, and terminal segments of the abdomen were detached. The terminalia was mounted ventral side up. When associated reared material was mounted, the larval and pupal pelts and the adult were all placed on the same slide, each under a separate cover slip. The operculum and respiratory horns were detached from the pupal pelt to facilitate examination. The frontoclypeus of the larval head capsule was generally detached and the head capsule mounted dorsal side up.

NOTES ON DISTRIBUTION RECORDS AND TAXONOMIC CITATIONS

Records of the North American distribution of *Culicoides* species given here are based on the review of Fox (1955), with additions

by later workers who described new species or added to the known distribution of already named species. These are summarized in the form of lists of the states and provinces from which a given species has been recorded. To avoid repetition, the source of records subsequent to Fox usually is not given, but is contained in one or more of the following papers: Beck, 1956, 1958 (Fla.); Coher *et al.*, 1955 (New England); Downes, 1958a (Canada); Fallis & Bennett, 1960 (Ont.); Forattini, 1957 (Central and South America); Jamnback *et al.*, 1958 (N. Y.), Jamnback & Wirth, 1963 (N. Y.); Jones, 1956 (Wisc.); Jones & Wirth, 1958 (Tex.); Lewis, 1959 (Conn.); Snow *et al.*, 1957 (Ala., N. C., Tenn., Va.); Vargas, 1958 (Mexico); Williams, 1955a, b, 1956a (Ga., Mich., Bermuda); Wirth & Bottimer, 1956 (Tex.); Wirth & Blanton, 1959 (Panama).

In several cases a species, or species group, has recently been redefined. In these instances the earlier records are not cited, e.g., *piliferus* gp. (Wirth & Hubert, 1962); *obsoletus* gp. (Jamnback & Wirth, 1963); *variipennis* subspecies (Wirth & Jones, 1957).

Within the State, distribution records are given in considerable detail unless already published elsewhere, or unless the species is widely distributed and common, in which cases only county records are given. In general, the less known about a species and the fewer collection records, the more detailed the citations.

Taxonomic citations usually include only the most recent comprehensive study, except that all North American records of the immature stages are included.

SUBGENERA AND SPECIES GROUPS

The subgeneric and species groupings of *Culicoides* occurring in New York State and their included species are given in table 2. The subgenera *Avaritia*, *Hoffmania*, *Monoculicoides*, and the *guttipennis* and *segnis* groups each form distinctive and discrete units in both adult and immature stages (where known). *Beltranmyia*, *Oecacta* (*furens* and *piliferus* groups), and the *biguttatus* group form less homogeneous units when both adult and immature stages are considered, probably because, in dealing with a limited fauna, several groups of more or less closely related species have been "lumped." The subgeneric and species groupings, as used here, are defined as follows:

TABLE 2. Subgenera and species groups in the genus *Culicoides* as it occurs in New York State

Subgenus or species gp.	Included species	Known immature stages	
		Pupae	Larvae
<i>Avaritia</i> Fox, 1955	<i>chiopterus</i>	+	+
	<i>obsoletus</i>	+	+
	<i>sanguisuga</i>	+	+
<i>Hoffmania</i> Fox, 1948	<i>venustus</i>	+	++
<i>Monoculicoides</i> , Khalaf, 1954 (as restricted by Fox, 1955)	<i>variipennis</i>	+	+
<i>Guttipennis</i> gp.	<i>arboricola</i>	+	—
	<i>flukei</i>	++	++
	<i>guttipennis</i>	+	+
	<i>villosipennis</i>	+	++*
<i>Beltranmyia</i> Vargas, 1953	<i>bermudensis</i>	++	++*
	<i>crepuscularis</i>	+	++
	<i>hollensis</i>	+	+
	<i>sphagnumensis</i>	—	—
	<i>wisconsinensis</i>	++	++
<i>Occacta</i> (Poey, 1851)	<i>baucii</i>	+	—
<i>furcens</i> gp.	<i>dickei</i>	—	—
	<i>furcens</i>	+	+
	<i>furcensoides</i>	—	—
	<i>haematopotus</i>	+	++
	<i>stellifer</i>	+	++
<i>piliferus</i> gp.	<i>alexanderi</i>	—	—
	<i>bicklei</i>	++	++
	<i>denticulatus</i>	++	++*
	<i>downesi</i>	—	—
	<i>jannbacki</i>	++	++
	<i>piliferus</i>	++	++
	<i>pseudopiliferus</i>	++	—
	<i>scanloni</i>	—	—
	<i>testudinalis</i>	++	—
	<i>utorwana</i>	++	++*
<i>Biguttatus</i> gp.	<i>biguttatus</i>	+	++*
	<i>loisae</i>	++	—
	<i>melleus</i>	+	+
	<i>niger</i>	+	—
	<i>spinosus</i>	++	—
	<i>travisi</i>	++	++*
<i>Segnis</i> gp. (Campbell & Pelham-Clinton, 1960)	<i>stilobezzioides</i>	—	—

* Larvae known only from head capsule and cast skin.

+ Previously described; ++ not previously described; — not known.

Subgenus AVARITIA

Male terminalia with apicolateral processes absent (except *chiopterus* short and stout); parameres separate, each gradually tapering to a fine distal point which is bare or has only fine microscopic hairs; basistyle with dorsal and ventral roots long, simple, subequal. *Female* with contiguous eyes; sensilla on antennomeres 3, 11-15; wing with apical portion of second radial cell in pale spot, macrotrichia sparse; spermathecae 2, subequal with short to very short slightly tapering necks. *Pupa* with long hairlike spines on operculum; *ad* setae long, subequal; last abdominal segment with a transverse band of spines across disc. *Larva* with unique small eyes made up of a single pigmented spot on each side; head very short; thorax unpigmented dorsally, with lateral pigmented spots on each segment at midlength.

Subgenus HOFFMANIA

Male terminalia similar to *chiopterus*, except apicolateral processes present, small although well defined; ninth tergite strongly tapering; ventral root simple, moderately short; dorsal root very short or apparently absent. *Female* similar to *Avaritia* but with different and more pronounced wing markings; second radial cell entirely in pale spot. *Pupa* with short, stout spines on operculum, with unique elongate nodule near posterior end; *ad* setae long, subequal; last abdominal segment with a v-shaped patch of spines on disc; horn unique in having no lateral spiracular openings and having tracheal rings extending two-thirds horn length. *Larva* unique (among species collected so far in larval stage) in having brown head capsule; thorax with faint-purplish pigmented spots, most abundant on prothorax, often faint; no lateral pigmented spots.

Subgenus MONOCULICOIDES

Male terminalia with well developed apicolateral processes; parameres fused basally, terminating distally in two fine bare points; ventral root moderately long; dorsal root very short. *Female* with widely separated eyes; sensilla on antennomeres 3, 8-10; wing with distinct pattern of lighter and darker markings, with second radial cell in dark area; macrotrichia moderately abundant; one C-shaped

spermatheca. *Pupa* with operculum densely covered with short spines except on posterior fifth; *ad* setae very unequal; last abdominal segment without patch of spines on disc. *Larva* with head strongly tapered anteriorly; thorax with dorsal surface covered with reddish-brown mottled pigmentation; unique massive pharyngeal sclerites.

Subgenus OECTACTA

Male terminalia with well developed apicolateral processes; parameres often swollen at midlength, separate, terminating in a series of spines; ventral root "boat-hook" shaped; dorsal root long and simple.

FURENS GROUP

Female with eyes narrowly to moderately separated; sensilla on antennomeres 3, 7 or 8-10 (except *haemotopotus* 3, 5-15); wing well marked with second radial cell in dark area, macrotrichia moderately abundant; spermathecae subequal, with long parallel-sided necks. *Pupa* with short to moderately long opercular spines; *ad* setae very unequal; last abdominal segment with or without a patch of spines; horn transversely convoluted near midlength. *Larva* with thoracic pigmentation varying, from extensive over most of dorsum, to faint lateral spots only.

PILIFERUS GROUP

Female with eyes narrowly to moderately separated (sometimes variable contiguous) sensilla typically 3, 5, 7, 9, 11-15 but reduced in many species. Wing sometimes with typical *piliferus* pattern with pale spots straddling midlength of veins M_1 and M_2 , but pattern often reduced to very faint or absent with only pale spots over r-m cross-vein, and just the distad of second radial cell apparent; macrotrichia usually moderately abundant; spermathecae 2, may be subequal but often unequal or very unequal, necks usually absent. *Pupa* with opercular spines often confined to lateral margins and disc papillate, but some with short spines on disc; *ad* setae very unequal; last abdominal segment with or without spines on disc. *Larva* with thorax unpigmented dorsally except for transverse bars sometimes present near anterior segment margins with well developed lateral spots, especially on meso- and metathoracic segments.

Subgenus BELTRANMYIA

Male terminalia with well developed apicolateral processes; parameres separate, tapering to fine bare points; ventral root moderately long, blunt; dorsal root very short or absent. *Female* with eyes narrowly to widely separated; sensilla on all flagellomeres in some species, and greatly reduced in others. Wings vary from very faintly marked to well marked; most have moderately abundant macrotrichia, with second radial cell dark; one subelliptical spermatheca. *Pupa* with opercular spines short to moderately long, *ad* setae very unequal; last abdominal segment with or without spines on disc. *Larva* with dorsum of prothoracic segment largely covered with pigmentation, meso- and metathoracic segments to a lesser extent; meso- and metathorax with more heavily pigmented round lateral spots.

GUTTIPENNIS GROUP

Male terminalia with well developed stout, often blunt apicolateral processes; parameres separate, simple, often swollen medially, each usually tapering to a bare rather blunt point; dorsal and ventral roots simple, subequal or ventral root shorter. *Female* with narrowly separated or variable contiguous eyes; sensilla on antennomeres 3, 5, 7, 9-15 (except *flukeyi* in which it is reduced to 3, 11-15). Wing with distinct markings, second radial cell entirely in dark area; macrotrichia abundant over most of wing; spermathecae two, subequal with short tapering necks. *Pupa* with operculum densely covered with short stout spines; *ad* setae very unequal; all abdominal segments densely covered with scale-like confluent spines, giving a unique reticulated appearance. *Larva* with head long and narrow; thorax unpigmented dorsally, with faint lateral pigmented spots on meso- and metathorax present or absent; last abdominal segment with unique (for *Culicoides*) long setae, longer than maximum width of segment.

BIGUTTATUS GROUP

Male terminalia with well developed apicolateral processes; parameres separate, often stout, tapering to a single bare point (except *loisae* and *spinosus*); ventral and dorsal roots simple, long, subequal. *Female* eyes and antennal sensilla variable as in *Beltranmyia*; wings often poorly marked except for pale spot over r-m cross-vein and just distad of second radial cell (*niger* wing well marked); two spermathecae with neck very short tapered or absent. *Pupa* with opercular spines short, *ad* setae very unequal; last abdominal seg-

ment with or without spines on disc. *Larva* of the one species known with dorsum of thorax unpigmented, with faint lateral thoracic spots.

SEGNIS GROUP

Male terminalia with well developed apicolateral processes, ninth tergite strongly tapering posteriorly; parameres separate, each tapering to a blunt point; aedeagus unique in having lateral arms forming an angle of 90 degrees or more; median posterior process short, concave at end; dorsal and ventral roots long, subequal blunt tipped. *Female* with narrowly separated eyes; sensillae on antennomeres 3-10; wings without pale spots, macrotrichia abundant; spermathecae two, unequal, with short tapering necks; with unique heavily sclerotized internal processes between spermathecae and copulatory bursa. *Pupa* and *larva* of North American species *stilobezzioides* and *bottimeri* unknown. This group, which includes three British species, is discussed by Campbell & Pelham-Clinton (1960).

DEFINITION AND EXPLANATION OF TERMS AND MEASUREMENTS USED IN DESCRIPTIONS AND KEYS

MALE

Workers since Carter *et al.* (1920) have relied largely on structures of the male terminalia in identifying *Culicoides*. Useful taxonomic characters include: the size and shape of the apicolateral processes of the ninth abdominal tergite (last segment), the degree and type of concavity of the posterior margin of the sternite of this segment, the size and shape of the dorsal and ventral roots of the basistyle, and the shape of the parameres and aedeagus. The pertinent structures are labelled in figures 1 and 2 and defined below.

Apicolateral processes

Paired posterior projections of the ninth tergum, one present on each side. These may be absent, small or large, stout or slender. To determine whether or not the apicolateral processes would touch if directed medially, the length of the process was compared to the distance from the inner base to the median notch or midline.

Parameres

Paired long, slender, sclerotized structures closely associated with the aedeagus. The various modifications of the base of the parameres do not lend themselves to short concise descriptions. If a piece projected at nearly right angles, as in *sanguisuga*, it was called a *flange*; where there was a secondary basal enlargement narrowly joined to the "base" of the paramere, as in *crepuscularis*, this was called an *accessory process*.

Aedeagus

The male copulatory organ consists typically of a median posterior process and two lateral anteriorly-directed arms. When the base (anterior) of the aedeagal arms was bent sharply outward, projecting at about right angles, the projecting portion was called a *flange* (figure 5).

Ninth sternum

The posterior margin of the ninth sternum usually has a concave emargination which may be broad and deep (*biguttatus*), broad and shallow (*crepuscularis*), narrow and deep (*furens*), cleft (*obsoletus*), or with little sign of an emargination (*stilobezzioides*). The membrane of the ninth sternum in the area of the emargination may be bare or *spiculate*. It is necessary to differentiate between the spicules actually on the membrane and the spicules of the intersegmental membrane between sclerites 8 and 9 since this is often folded back over part of segment 9.

FEMALE

Culicoides females possess a number of characters of taxonomic value, but except for the pattern of the wings and thorax, it is necessary to prepare slide mounts of the specimens for microscopic examination in order to compare them. Such mounts generally obscure the thoracic pattern, for that reason it is rarely mentioned in the descriptions. Useful characters include: the degree of eye separation, length of the proboscis, number of mandibular teeth, proportional lengths of the antennomeres, presence or absence of olfactory pits on the antennal segments, degree of swelling of the third segment of the maxillary palp and the size of its olfactory pit, leg banding, number of hind tibial spines, wing length, and structure and size of the spermathecae. The pertinent structures are defined below:

Wing length

Measured from wing tip to basal cross-vein (NOT increased by one-seventh to allow for portion of wing basad of cross-vein as in Jamnback & Wirth, 1963).

P/H ratio (proboscis to head index ratio)

The distance from the center of the median hair socket (interocular seta) to the tormae divided by the distance from the tormae to the tip of the labrum-epipharynx (figure 168). Proboscis lengths were classified as *short* if the P/H ratio was less than 0.65, *intermediate* if between 0.65 and 0.75, and *long* if more than 0.75.

AR (antennal ratio)

The combined length of the last five flagellomeres divided by the length of the first eight.

Maxillary palp

Slightly swollen (figure 104), with an L/W (length divided by width) ratio of more than 3.00; *moderately swollen* (figure 109), with an L/W ratio of 2.50 to 3.00; *greatly swollen* (figure 105), with an L/W ratio of less than 2.50. These ratios were determined after the degree of swelling on the palps of most of the species had been characterized. In general, the subjective terms and ratio limits agree well. In a few species, which have an unusually short third palpal segment, the ratio indicates that the palp is greatly swollen when it appears to be only slightly or moderately swollen. These instances are noted in the descriptions.

The eyes may be *contiguous*, *narrowly separated*, *moderately separated*, or *widely separated*. Figures 151, 154, 157, and 156 illustrate these terms. While the distance is rather constant in most species, in a few it varies from contiguous to moderately separated. All of these species have a superior transverse suture which is absent in species where the eyes are always contiguous.

Spermathecae

All species with two spermathecae also have a rudimentary spermatheca, and, excepting *loisae*, *melleus*, *spinosus*, and *stilobezzioides*, a sclerotized ring. Species with a single spermatheca have neither a rudimentary spermatheca nor a sclerotized ring.

PUPA

The pupae are less well known than the adults. The outstanding studies are those of Kettle & Lawson (1952) and Jones (1961a). Of the 37 species so far collected in New York State, 17 have been described previously, often in a very sketchy fashion. These are re-described here and the pupae of an additional 13 species described for the first time (table 2). Useful taxonomic characters include: shape and structure of the respiratory horn, and the size, number, and position of spines, setae, and tubercles on the operculum, cephalothorax, and abdomen. The terms applied to the spines and tubercles were first proposed by Carter *et al.* (1920 and have been used by most workers since. These are defined below and illustrated in figures 184, 185, and 186 (figure 185 is taken from Jones, 1961a).

The most useful taxonomically were the *d* (dorsal) tubercles. A series of 5 seta-bearing tubercles on each side of the cephalothorax close to the median line, as illustrated in figure 245. The *d* tubercles 1 to 3 are equidistant and in line in many species; in some, tubercles 1 and 2 are closer than 2 and 3, sometimes side by side; the lengths of seta 1 and 2 provide a useful taxonomic character, seta 3 is usually very short; tubercles and setae 4 and 5 are rather constant in size and position in the genus; seta 4 is rather long and seta 5 very short or apparently absent. The following three groups of thoracic tubercles proved to be of less value:

The *ad* (anterodorsal) tubercles. Located on each side of the cephalothorax between the *am* setae of the operculum and the respiratory horn. Each has a pair of setae which are either very unequal or, in a few species, subequal in length.

The *am* (anteromarginal) tubercles. Located on the operculum, one on each side just anterior to the lateral points, each bears a well developed seta.

The *dl* (dorsolateral) tubercles. Located on the cephalothorax, one on each side just laterad of, and slightly anterior to, the base of the respiratory horn. In the species studied, each tubercle had 3 setae, one long and two short. One of the short ones arises at the base of a cleft in the tubercle, making it difficult to locate even when examined under oil immersion.

The most useful tubercles on the abdomen were the *lpm* (lateral postmarginal) tubercles. These consist of a series of three seta-bearing tubercles near the posterior margin on both sides of the abdominal segments; the seta on the middle of the three tubercles is more slender and longer than those on each side. This provides a useful landmark when examining pupal pelts since the *lpm* tubercles

are in line with, and often difficult to distinguish from, the *vpm* and *dpm* tubercles as figure 185 indicates. The *lpm* tubercles on abdominal segments 4 to 6 were examined for taxonomic details since the number of tubercles on segments 1, 2, and 8 are reduced and are absent on segment 9 (the last).

LARVA

The larvae of North American *Culicoides* are less well known than the pupae. Eight of the 37 New York State species have been described previously. These are redescribed, and an additional 15 species described for the first time. In some cases, the descriptions are very incomplete, being based on fragments of the head capsule. Fourteen of the species occurring in the State are not known in the larval stage (table 2).

The descriptions are based primarily on head length and pigmentation, structure of the pharyngeal apparatus, and thoracic pigmentation, characters that Kettle & Lawson (1952) found useful in their outstanding study of the larvae of British *Culicoides*. The terms used in these descriptions are defined below and illustrated in figures 268 to 291.

Frontoclypeus

Dorsal sclerite of the head capsule. The length of the frontoclypeus rather than the total head length was used as an index to head length because it was usually necessary to destroy portions of the capsule in dissecting out the pharyngeal apparatus, making total length measurements impossible. The frontoclypeus makes up about 96 percent of the dorsal head length.

Comb

The pharyngeal apparatus of *Culicoides* larvae consists of an epipharynx and a hypopharynx. The epipharynx is made up, in part, of a median series of overlapping "combs" (usually four). The dorsalmost of these is the largest and most conspicuous, extending posteriorly beyond the more ventral combs. For purposes of this paper, only the conspicuous dorsal comb was examined and measured, and is the structure referred to as the comb. The number of comb teeth and width of the comb is of some (limited) taxonomic value for New York specimens. The hypopharynx appeared to be quite uniform in the species studied and was not included in the descriptions.

Thoracic pigmentation

The thoracic markings are of considerable value in distinguishing species. One type of marking consists of paired lateral round, oval, or irregular spots usually located at about midlength of the segments (often absent on the prothorax). A second type consists of a more diffuse dorsal pigmentation, often covering the entire dorsum. Usually it is more pronounced on the prothorax, less so on the mesothorax, and is still fainter or absent on much of the metathorax.

NUMBERS OF SPECIMENS MEASURED

Measurements and ratios of structures of taxonomic importance in both the adult and immature stages were made from slide-mounted specimens. Although all of the slides in the New York State Museum collection and some from the U.S. National Museum were examined, only five specimens of each stage (when available) were measured to provide an estimate of the degree of infraspecific variation to expect in a given structure and a given species. In cases where fewer than five specimens were measured, the number is given in parentheses following the measurement average and range, as follows: 7.5(5-10, $n = 4$), where n equals the number measured. In cases where five specimens were measured the $n = 5$ is omitted.

KEYS TO MALES, FEMALES, PUPAE, AND LARVAE

Heleids can be distinguished from other Nematocerous Diptera using characters given by Wirth & Stone, 1956. Larvae of *Alluaudomyia*, *Ceratopogon*, and *Stilobezzia* closely resemble those of *Culicoides*; but larvae of these genera usually possess long perianal setae lacking in *Culicoides* (except that *guttipennis* group larvae, which are all treehole breeders, also have long perianal setae).

The identification of many *Culicoides* cannot be safely undertaken without preparing series of slide-mounted specimens until one becomes familiar with the species present in a given area and their seasonal distribution. Even then, a portion of the identified series should be mounted for confirmation of identification.

The keys presented here follow "natural" groupings insofar as they provide useful taxonomic characters without unnecessarily

complicating identification. Since it is not always possible to key every species using the most conspicuous distinguishing character first, a list of these useful sorting characters and the species which possess them is given following each key. Characters that occur early in the key are not repeated there.

KEY TO CULICOIDES MALES COLLECTED IN NEW YORK STATE⁴

1. —Parameres fused at base, divided distally;
aedeagus with median posterior process
divided on midline distally *variipennis*
—Parameres separate; aedeagus with median
posterior process not divided on midline dis-
tally 2
2. —Ventral root "boat-hook" shaped; base of
paramere simple, slightly swollen; tips of
parameres with a series of six or more spines 3
—Ventral root simple or absent, base of
parameres swollen, lobed, or with accessory
process, tips without spines (except *spinusus*
and *loisae* which terminate in four large
spines) 9
3. —Aedeagus with long parallel-sided median
posterior process and two short lateral pos-
terior processes; emargination of ninth ster-
num narrow and shallow 4
—Aedeagus with shorter median posterior
process and no lateral posterior processes;
emargination of ninth sternum narrow and
deep 5
4. —Paramere swollen just distad of midlength;
ninth tergum strongly tapered posteriorly;
lateral arms of aedeagus shorter *haematopotus*
—Paramere not swollen at midlength; ninth
tergum less strongly tapered posteriorly;
lateral arms of aedeagus longer *bauceri*

⁴ Species not included in key: *alexanderi*, *bermudensis*, *utowana*.

- | | |
|---|-----------------------------------|
| 5. —Paramere swollen just distad of midlength | 6 |
| —Paramere not swollen just distad of midlength | 7 |
| 6. —Swollen lobe at midlength of paramere smaller, a fresh-water species | <i>furensoides</i> |
| —Swollen lobe on paramere larger, a salt-marsh species | <i>furens</i> |
| 7. —Aedeagus with median posterior process rounded distally, lateral arms with short basal flange | <i>dickei</i> |
| —Aedeagus with median posterior process truncate and ridged distally, lateral arms with long basal flange | 8 |
| 8. —Paramere expanded at tip with a comb of spines | <i>stellifer</i> |
| —Paramere tapering to a fine distal point with a row of spines along margin | <i>piliferus</i> gp. ⁵ |
| 9. —Ventral root absent or represented by a small protuberance | 10 |
| —Ventral root longer tapering or parallel sided | 15 |
| 10. —Ninth tergum strongly tapered posteriorly, apicolateral processes very small; aedeagus with a sclerotized membrane between lateral arms extending anteriorly almost to base and a transverse bar across base | <i>venustus</i> |
| —Ninth tergum slightly tapered posteriorly, apicolateral processes large, aedeagus without such a sclerotized membrane | 11 |
| 11. —Aedeagus with median posterior process terminating in a nipple-like apex, membrane of ninth sternum not spiculate | <i>flukei</i> |
| —Aedeagus evenly rounded or truncate at apex | 12 |
| 12. —Membrane of ninth sternum not spiculate | <i>spagnumensis</i> |
| —Membrane of ninth sternum spiculate | 13 |
| 13. —Basal half or more of dististyle swollen; median posterior process of aedeagus truncate; wing faintly marked | <i>hollensis</i> |
| —Less than half of basistyle swollen | 14 |

⁵ *bickleyi*, *denticulatus*, *downesi*, *jamnbacki*, *piliferus*, *pseudopiliferus*, *scanloni*, *testudinalis*.

14. —Apicolateral processes longer, would barely touch if directed medially; paramere joined to accessory process at about right angle; wing poorly marked *wisconsinensis*
—Apicolateral processes shorter, would not touch if directed medially; paramere joined to accessory process at about 45 degree angle; wing conspicuously marked *crepuscularis*
15. —Ninth tergum without apicolateral processes; ninth sternum with a deep narrow cleft on midline of posterior margin 16
—Ninth tergum with distinct apicolateral processes; ninth sternum with a concave emargination 17
16. —Median posterior process of aedeagus longer, concave tipped, sides usually spinulose, lateral arms curving slightly posterolaterally beside median posterior process, arms short; tip of paramere bare *sanguisuga*
—Median posterior process shorter, rounded apically, sides not spinulose; lateral arms sloping anterolaterally beside median posterior process, arms long; tip of paramere with microscopic hairs *obsoletus*
17. —Ninth tergum strongly tapered posteriorly; paramere with a row of about 5 long hairs near tip; median posterior process represented only by a concavity when viewed from ventral aspect *stilobezzioides*
—Ninth tergum less tapered posteriorly; paramere without hairs; median posterior process well developed projecting posteriorly 18
18. —Tip of paramere divided into 4 spines 19
—Tip of paramere evenly tapered terminating distally in a single tip 20
19. —Apicolateral processes would not touch if directed medially; median notch between processes indicated only by a slight depression *loisae*
—Apicolateral processes would touch if directed medially; median notch between processes deeply concave or broadly and deeply v-shaped *spinosus*

20. —Aedeagus with a sclerotized membrane extending transversely between lateral arms and extending anteriorly almost to base *chiopterus*
 —Aedeagus without sclerotized membrane between lateral arms, or if present, only near apex of arch 21
21. —Paramere abruptly swollen just basad of midlength *niger*
 —Paramere not swollen near midlength 22
22. —Median posterior process short 23
 —Median posterior process long 24
23. —Median posterior process of aedeagus terminating in a cap-like structure (figure 13) *melleus*
 —Median posterior process of aedeagus not terminating in a cap-like structure *biguttatus*
24. —Median posterior process ending in three distal lobes *villosipennis*
 —Median posterior process ending in a single tip 25
25. —Dististyle strongly curved at midlength; ventral root short *guttipennis*
 —Dististyle slightly curved at midlength; ventral root elongate, simple 26
26. —Median posterior process tapered, ending in a fine blunt point *arboricola*
 —Median posterior process nearly parallel-sided, ending in a broad blunt point or apparently truncate *travisi*

Useful Sorting Characters for *Culicoides* Males

1. Ninth tergum strongly tapered posteriorly; *haematopotus*, *stilobezzioides*, *venustus*.
2. Parameres with long hairs near tip; *stilobezzioides*.
3. Parameres with short microscopic hairs near tip; *obsoletus*, *venustus*.
4. Parameres with spines near tip; *Oecacta* spp., *loisae*, and *spinosus*.
5. Aedeagus with sclerotized membrane extending transversely between lateral arms almost to base; *chiopterus*, *venustus*.
6. Ninth sternum with spicules on membrane; *bermudensis*, *biguttatus*, *crepuscularis*, *hollensis*, *melleus*, *wisconsinensis*.

7. Apicolateral processes:

- a. absent: *obsoletus*, *sanguisuga*.
- b. very small; *venustus*.
- c. long and stout, they would touch if directed medially; *arboricola*, *flukei*, *melleus*, *travisi*, *villosipennis*.
- d. long and slender, they would touch if directed medially; *furens*, *furensoides* (1 of 2 specimens examined), *spinosus*, *stilobezzioides*, *wisconsinensis*.

In the key to females, *Monoculicoides*, *Beltranmyia*, and *Avaritia* are keyed out first. These are followed by species with reduced mouthparts that represent several species groups; after these, the *piliferus* group, the *furens* group, the *guttipennis* group, and the *biguttatus* group are keyed out in turn.

KEY TO CULICOIDES FEMALES COLLECTED IN NEW YORK STATE

1. —One spermatheca 2
 —Two spermathecae (occasionally the rudimentary spermatheca is well developed so that 3 large spermathecae are present) 7
2. —Spermatheca C-shaped, 6 hind tibial spines, wing with a pattern of distinctive gray streaks *variipennis*
 —Spermathecae subelliptical, 4 hind tibial spines 3
3. —Eyes narrowly separated; all flagellomeres with sensilla, first 8 segments moniliform, each about as broad as long 4
 —Eyes widely separated; most antennal segments lack sensilla, present on 3, 13-15 or 3, 11-14, first 8 flagellomeres each distinctly longer than broad 5
4. —First 8 flagellomeres very short, $AR=1.9$; third palpal segment greatly swollen with large but shallow sensory pit *sphagnumensis*
 —First 8 flagellomeres longer, $AR=1.4$; third palpal segment greatly swollen with a large and deep sensory pit *crepuscularis*

5. —Third palpal segment slightly swollen, sensory pit shallow; about 13 mandibular teeth; salt-marsh species *hollensis*
 —Third palpal segment moderately to greatly swollen, sensory pit large; not more than 8 mandibular teeth 6
6. —Spermatheca unusually large, about 123 microns maximum width, lightly pigmented; sensillar pattern 3, (11)⁶, (12), 13, 14; wing markings very distinct *bermudensis*
 —Spermatheca about 70 microns maximum width, heavily pigmented; sensillar pattern 3, (4), (5), (7), (8), 11, 13, 14, wing markings faint *wisconsinensis*
7. —Eyes touching in front, without superior transverse suture; 5 hind tibial spines 8
 —Eyes not touching in front, or, if touching, with superior transverse suture; 4 or 5 hind tibial spines 11
8. —Vien Cu₁ lying in a narrow light area for its entire length; legs with distinct pale bands, especially base of hind tibia, "knees" pale *venustus*
 —Vien Cu₁ lying in a dark area, not bordered by a light spot; legs without distinct pale bands 9
9. —P/H ratio 0.59-0.74; mandible with fewer than 10 teeth; third palpal segment very short, not more than 1.2 times as long as fifth; eye angle usually obtuse; wing entirely grayish hyaline with very few macrotrichia; scutum dull brownish black with greenish pruinosity *chiopterus*
 —P/H ratio 0.80 or more; mandible with 12-15 teeth; third palpal segment longer, at least 1.5 times as long as fifth segment; eye angle usually acute 10
10. —Thorax dull dark brown, usually with sub-lateral darker vittae; third palpal segment moderately swollen, widest a small distance from apex; wing with more numerous macro-

⁶ Sensilla occasionally present on antennomeres indicated in parentheses.

- trichia and usually with more distinct markings *obsolctus*
- Thorax subshining, light brown grayish pruinosity; third palpal segment slightly swollen, widest near apex; wing usually with fewer macrotrichia; wing markings usually paler *sanguisuga*
11. —Proboscis short, mandible with not more than 8 teeth 12
- Proboscis usually long or intermediate, if short mandible with at least 10 teeth 17
12. —Tip of labrum with fleshy, distal, conical prolongation 13
- Tip of labrum without prolongation 16
13. —Sensillar pattern 3, 8-10; wing with distinct discal pale spots *dickei*
- Sensillar pattern 3, 11-15; wing with discal pale spots faint or absent 14
14. —Spermathecae very unequal; necks absent or very short parallel sided *utowana*
- Spermathecae subequal, necks moderately long to long parallel sided or slightly tapered 15
15. —Mandibular teeth absent; 4 hind tibial spines *loisae*
- Mandibular teeth 4-6; 5 hind tibial spines *denticulatus*
16. —Third segment of maxillary palp greatly swollen, globose; sensory pit deep with large opening; sensillar pattern 3, 11-15 *flukei*
- Third segment of maxillary palp moderately swollen with shallow sensory pit; sensillar pattern 3, 8-10 *furensoides*
17. —Spermathecae unequal or very unequal usually subelliptical with neck absent or very short parallel sided 18
- Spermathecae equal or subequal, neck either long parallel sided or short strongly tapered 25
18. —First 8 flagellomeres very short, at most slightly longer than broad; $AR=1.6$ or more; wing markings distinct 19
- First 8 flagellomeres longer than broad, $AR=1.4$ or less; wing markings distinct or faint 20

19. —First 8 flagellomeres moniliform, $AR = 1.66-2.08$; sensillar pattern 3, 5, 7, (8), 9, (10), 11-15; third palpal segment greatly swollen with round pit; 12-15 mandibular teeth; small species, wing 0.99-1.38 mm. *piliferus*
 —First 8 flagellomeres slightly longer than broad, $AR = 1.63-1.72$; sensillar pattern 3, 5, 7, 9, 11-15; third palpal segment moderately swollen with irregular shallow pit; 15-19 mandibular teeth; very large species, wing 1.45-1.72 mm. long *downesi*
20. —Wing without discal pale spots; sensillar pattern 3, (5), 7, 9, (11), 13-15 *jamnbacki*
 —Wing with distinct discal pale markings, including pale spots over midveins M_1 and M_2 ; sensillar pattern 3, (5), (7), (9), 13-15 21
21. —Thorax light brown; sensillar pattern, 3, 13-15 (occasionally on 5 or 7 or 9) *bickleyi*
 —Thorax dark brown; sensilla always present on antennomeres 5, 7, and 9 22
22. —Eyes narrowly separated; proboscis short, P/H ratio 0.58-0.69 *alexanderi*
 —Eyes moderately to broadly separated; proboscis long, P/H ratio 0.74-0.93 23
23. —Small species, wing length 0.87 ($n=1$); sensillar pattern 3, 5, 7, 9-15 *scanloni*
 —Larger species, wing length 1.08-1.22; sensilla absent on antennomeres 10 and 12 24
24. —Sensillar pattern 3, 5, 7, 9, 13-15; discal spots on wing faint or absent *testudinalis*
 —Sensillar pattern 3, 5, 7, 9, 11, 13-15; discal pale spots on wing more distinct *pseudopiliferus*
25. —Wing with distinct discal pale spots 26
 —Wing without discal pale spots 34
26. —Pale spot over r-m cross-vein does not extend basad of vein 27
 —Pale spot over r-m cross-vein extending basad of it 28
27. —Sensillar pattern 3, 5-15 *haematopotus*
 —Sensillar pattern 3-10 *baueri*
28. —Sensillar pattern 3, 8-10 or 3, 11-15 29
 —Sensilla present in other combinations,

- present on more than half of the flagellomeres 31
29. —Thorax with numerous small dark spots; 4 hind tibial spines; wing with distinctive pale spots as in figure 39; sensillar pattern 3, 8-10 *furens*
 —Thorax without dark spots; 5 hind tibial spines 30
30. —Sensillar pattern 3, 8-10; wing pattern as in figure 56 *stellifer*
 —Sensillar pattern 3, 11-15; wing pattern as in figure 55 *spinus*
31. —Wing with a row of confluent pale spots beginning just distad of second radial cell, without more distal pale spots; sensilla present on all flagellomeres *niger*
 —Sensillar pattern 3, 5, 7, 9, 11-15; wing without a row of pale spots 32
32. —Wing with light spot over r-m cross-vein small, not extending below vein M_1 *villosipennis*
 —Wing with light spot over r-m cross-vein large, extending below vein M_1 33
33. —Wing with vein Cu_1 in pale area *arboricola*
 —Wing with vein Cu_1 entirely in dark area *guttipennis*
34. —Wings uniform in color 35
 —Wing with 2 pale spots, one over r-m cross-vein and the other just distad of second radial cell 36
35. —A pale yellow species with light wings; third segment of maxillary palp with very shallow sensory areas scattered over surface, without a well developed sensory pit; sensillar pattern 3, 10-14, a coastal species *melleus*
 —A dark species; third segment of maxillary palp with well developed pit; sensillar pattern 3-10 *stilobezzioides*
36. —Sensilla present on all flagellomeres; spermathecae without necks *travisi*
 —Sensillar pattern 3, (5), 7, 9, (10), 11-15, spermathecae with blunt sharply tapered necks *biguttatus*
 —Sensillar pattern 3, 11-15; spermathecae with long slightly tapered necks *spinus*

Useful Sorting Characters for Culicoides Females

1. Wings (see figures 27 to 64):
 - a. with unique markings for species: *arboricola*, *baueri*, *crepuscularis*, *dickei*, *furens*, *furensoides* (close to *dickei*), *guttipennis*, *haematopotus*, *niger*, *mellens* (the only yellow species), *stellifer*, *stilobezzioides*, *variipennis*, *venustus*, *villosipennis*.
 - b. with distinct *piliferus* group markings; *alexanderi*, *bicklei*, *downesi*, *flukei* (superficially quite similar to the *piliferus* group), *piliferus*, *pseudopiliferus*, *scanloni*.
 - c. with faint to distinct *obsoletus* group markings; *chiopterus*, *obsoletus*, *sanguisuga*.
 - d. with distinct *biguttatus* type marking and no trace of light spots elsewhere; *biguttatus*, *jamnbacki*.
 - e. with variable faint to distinct markings over r-m cross-vein, just distad of second radial cell and on disc and near the lateral and posterior margins; *bermudensis*, *denticulatus*, *hollensis*, *loisae*, *spinosus*, *sphagnumensis*, *testudinalis*, *travisi*, *utowana*, *wisconsinensis*. The spots over the r-m cross-vein and distad of the second radial cell are often more distinct than the discal and marginal spots.
2. Species with eyes widely separated; *bermudensis*, *hollensis*, *pseudopiliferus*, *testudinalis*, *variipennis*, *wisconsinensis*.
3. Species with first 8 flagellomeres short, each about as wide as long; combined length much less than that of last 5 segments, $AR = 1.60$ or more; *downesi*, *haematopotus*, *piliferus*, *sphagnumensis*, *stilobezzioides*.
4. Third segment of maxillary palp greatly swollen: *baueri*, *bermudensis*, *crepuscularis*, *flukei*, *haematopotus*, *niger*, *piliferus*, *sphagnumensis*, *stilobezzioides*, and *travisi*.
5. Sensillar patterns:
 - a. 3-15; *crepuscularis*, *niger*, *sphagnumensis*, *travisi*.
 - b. 3, 5-15; *haematopotus*.
 - c. 3-10; *baueri*, *stilobezzioides*.
 - d. 3, 5, 7, 9, (10), 11-15; *arboricola*, *downesi*, *guttipennis*, *piliferus*^{*}, *scanloni*, *villosipennis*.
 - e. 3, 7, 9, 11-15; *biguttatus*^{*}.
 - f. 3, 5, 7, 9, 13-15; *alexanderi*, *testudinalis*.
 - g. 3, 5, 7, 9, 11, 13-15; *pseudopiliferus*.
 - h. 3, 7, 9, 13-15; *jamnbacki*.

^{*} Asterisks indicate species that often have supernumerary sensilla on antennomeres in addition to those indicated.

- i. 3, 11-15; *chiopterus*, *denticulatus*, *flukei*, *loisae*, *obsoletus*, *sanguisuga*, *spinus*, *utowana*, *venustus**
- j. 3, 10-14; *melleus*.
- k. 3, (11), (12), 13, 14; *bermudensis*.
- l. 3, 7-10; *furens*.
- m. 3, 8-10; *dickei*, *furensoides*, *stellifer*, *variipennis*.
- n. 3, 11, 13, 14; *wisconsinensis**
- o. 3, 13-15; *bickleyi**, *hollensis**

In the key to the pupae, *Avaritia*, *Hoffmania*, and the *guttipennis* group are keyed out in order with a few species from other groups. Thereafter, the species are keyed out individually for the most part, with little reference to their "natural" relationships. *Beltranmyia* and *Oecacta* (*furens* group and *piliferus* group provide a mosaic of useful characters that do not closely follow subgeneric or species group lines. The pupae of *bickleyi* could not be separated from *jamnbacki*, nor *biguttatus* from *travisi*, with any degree of certainty.

KEY TO CULICOIDES PUPAE COLLECTED IN NEW YORK STATE⁸

1. —*ad* setae long and subequal; *d* seta 2 longer than 1 or very long subequal (*hollensis*) (figure 254) 2
 - ad* setae very unequal; *d* setae 1 and 2 never very long; 1 longer than 2 or equal (figure 245) 6
2. —Operculum with very long hair-like spines, about as long as one-fourth maximum width of operculum 3
 - Operculum with spines not more than one-tenth as long as maximum width of operculum 5
3. —Horn uniformly brown to dark brown; longer anterodorsal seta longer than respiratory horn *chiopterus*
 - Horn mostly or entirely pale yellow;

⁸ Species not included in key: *alexanderi*, *dickei*, *downesi*, *furensoides*, *scanloni*, *sphagnumensis* and *stilobezzioides*.

- longer anterodorsal seta subequal to or shorter than respiratory horn 4
4. —Horn uniformly pale yellow; operculum lacking a series of short spines along lateral margin behind long spines *sanguisuga*
 —Horn pale yellow with basal portion clouded with light brown (sometimes faint); operculum with a series of short spines along lateral margins behind long spines *obsoletus*
5. —Horn with no lateral spiracular openings; operculum with elongate nodule on midline near posterior margin; *d* seta 2 longer than 1 *venustus*
 —Horn with 4-6 lateral spiracular openings; operculum without nodule; *d* setae 1 and 2 very long, subequal *hollensis*
6. —Abdominal segments entirely covered with confluent scale-like spines giving a reticulated appearance (figure 187) 7
 —Abdominal segments with spines not confluent and scale-like, less abundant, in most species confined to transverse row near anterior margins of segments 8
7. —Horn short and stout, widest near tip, L/W ratio 3.6-5.3; 11-15 apical spiracular openings *guttipennis*
 —Horn more elongate and slender, widest near base, L/W ratio 5.3-6.8; not more than 12 spiracular openings *arboricola*
flukei
villosipennis
8. —Horn with rounded transverse convolutions near middle, narrowed; lateral spiracular openings on conspicuous protuberances 9
 —Horn not narrowed medially or with rounded transverse convolutions near middle; scale-like transverse spines sometimes present, lateral spiracular openings on slightly to moderately swollen areas 13
9. —Horn with 15-20 apical and 4-7 lateral spiracular openings; all lateral spiracular openings on a single protuberance near base *melleus*
 —Horn with not more than 8 apical and 4

- lateral spiracular openings, lateral ones each
on a separate protuberance 10
10. —*lpm* tubercles rounded or ridged apically 11
—*lpm* tubercles strongly bifid 12
11. —*d* tubercles 1-3 in line, about equidistant;
operculum with long spines abundant over
most of surface *baueri*
—*d* tubercles 1-3 not in line or equidistant,
with tubercles 1 and 2 almost side by side
and touching; operculum with moderately
long spines along lateral margins and disc,
bare posteriorly *haematopotus*
12. —Operculum with long spines; last ab-
dominal segment without a patch of spines on
disc *furens*
—Operculum with short spines; last ab-
dominal segment with a patch of spines on
disc *stellifer*
13. —Horn with 10 or more apical spiracular
openings 14
—Horn with 3 to 9 apical spiracular open-
ings 15
14. —*lpm* tubercles bifid; shape of horn dis-
tinctive (figure 213) *variipennis*
—*lpm* tubercles rounded or weakly ridged;
horn similar to that of many other species
(figure 216) *wisconsinensis*
15. —Horn pale, distinctly darkened apically 16
—Horn uniformly brown to dark brown, may
be slightly darkened distally (usually not) 19
16. —Operculum with long spines *bermudensis*
—Operculum with short spines or papillate
surface 17
17. —Operculum with true spines confined to
lateral margins, disc papillate; last segment
without patch of spines *ulowana*
—Operculum with true spines both on lateral
margins and disc; last segment with a patch
of spines 18
18. —Operculum densely covered with short
spines except near posterior end *crepuscularis*
—Operculum with slightly longer spines

- moderately abundant, confined to lateral margins and disc *spinosus*
19. —Operculum with distinct pointed spines both along lateral margins and on disc, or disc smooth 20
 —Operculum with papillae or papilliform spines (rounded tips) on disc 21
20. —Disc of operculum bare; *lpm* tubercles with single point or rounded *loisae*
 —Disc of operculum densely covered with short stout spines; *lpm* tubercles rounded or ridged *biguttatus travisi*
21. —Abdominal segments with spines mostly confined to transverse band near anterior margin of each segment, sparse elsewhere *niger*
 —Abdominal segments with spines moderately abundant, scattered over entire segment in addition to transverse band 21
22. —*lpm* tubercles with a single point or (rarely) weakly bifid 23
 —*lpm* tubercles strongly bifid 24
23. —Respiratory horn slender, narrowed near middle; thoracic surface between *d* tubercles nearly smooth *piliferus*
 —Respiratory horn stouter, not narrowed near middle; thoracic surface between *d* tubercles strongly papillate *denticulatus*
24. —Respiratory horn moderately stout, with 8-9 apical spiracular openings; area between *d* tubercles papillate *pseudopiliferus*
 —Respiratory horn with 4-5 apical spiracular openings 25
25. —Respiratory horn slender; area between *d* tubercles weakly papillate *testudinalis*
 —Respiratory horn stouter; area between *d* tubercles nearly smooth. *bickleyi jamnbacki*

Useful Sorting Characters for Culicoides Pupae

1. a. Operculum with long spines (not very long as in *Avaritia*); *baueri*, *bermudensis*, *furens*, *haematopotus*, *hollensis*, *melleus*, (confined mainly to lateral margins in *melleus*).

- b. Operculum with short spines on lateral margins, disc papillose; *bickleyi*, *jamnbacki*, *niger*, *piliferus*, *pseudopiliferus*, *testudinalis* (?), *utowana*.
 - c. Operculum with short spines abundant over most of surface posterior to *am* tubercles, except at extreme posterior end; *arboricola*, *crepuscularis*, *denticulatus*, *flupei*, *guttipennis*, *variipennis*, *villosipennis*, *wisconsinensis*.
 - d. Operculum with short spines on lateral margins and disc; *biguttatus*, *spinosus*, *stellifer*, *travisi*, *venustus* (few or none on disc of *venustus*).
2. Last abdominal segment with a patch of spines on disc; *bickleyi*, *biguttatus*, *crepuscularis*, *denticulatus*, *haematopotus*, *jamnbacki*, *niger*, *piliferus*, *pseudopiliferus*, *spinosus*, *stellifer*, *testudinalis*, *travisi*, *venustus*. (Present as a transverse band of spines in *chiop-terus*, *obsoletus*, *sanguisuga*.)
3. Caudal apicolateral processes extending out at right angles to longitudinal axis of body; *hollensis*, *melleus*, *utowana*, *variipennis*.
4. a. *d* tubercles 1 and 2 closer than 2 and 3, not in line; *furens*, *haematopotus*, *hollensis*, *melleus*.
- b. *d* setae 1 and 2 long, subequal; *bermudensis*, *bickleyi*, *crepuscularis*, *denticulatus*, *hollensis*, *jamnbacki*, *loisae*, *melleus*, *niger*, *piliferus*, *stellifer*, *utowana*, *variipennis*, *wisconsinensis*.
- c. *d* setae 1 and 2 short, subequal; *arboricola*, *buguttatus*, *flupei*, *furens*, *guttipennis*, *haematopotus*, *spinosus*, *travisi*.

The key to the larvae is preliminary, being based on a limited number of species and for the most part, on limited material. It follows the example of Kettle & Lawson (1952) in using head lengths and thoracic pigmentation as basic taxonomic characters. The major difficulty encountered in the study of larva was the large number of species reared from the "generalized *Culicoides* breeding habitat (p. 7)." It was necessary to rear larvae from these habitats individually for positive association of the larval and pupal pelts, and the adults. With larvae it was further necessary to illustrate, at least diagrammatically, each larva before it pupated and the characteristic markings were lost. While the following key is an early step toward developing a reasonably reliable method of identifying the larvae, it has the advantage of including all of the species, which are important pests of man, occurring in the State.

PRELIMINARY KEY TO CULICOIDES LARVAE COLLECTED IN NEW YORK STATE⁹

1. Very large larva, about 8 mm. long; frontoclypeus 255-285 microns long, yellow, brownish posteriorly; pharyngeal apparatus massive, heavily sclerotized; dorsum of thoracic segments uniformly brownish; head capsule strongly tapered anteriorly *variipennis*
- Smaller larvae, less than 6 mm. long; frontoclypeus less than 240 microns (except *venustus*); pharyngeal apparatus not massive or heavily sclerotized, "typical" for genus 2
2. —Head capsule brown, frontoclypeus 235-279 microns long; thoracic dorsum with numerous discrete pigmented spots *venustus*
- Head capsule yellow, at most tinged with brown, frontoclypeus less than 228 microns (except *guttipennis*) 3
3. —Setae on last abdominal segment long, longer than maximum width of segment 4
- Setae on last abdominal segment short, less than half as long as maximum width of segment 6
4. —Frontoclypeus 164 microns long ($n=1$); comb width 11 microns, with 4 equal teeth on each side *flukei*
- Frontoclypeus more than 200 microns long 5
5. —Frontoclypeus 229-248 microns long; comb width 26-33 microns with 5-7 teeth on each side *guttipennis*
- Frontoclypeus 218 microns long ($n=1$) *villosipennis*
6. —Dorsum of thorax pigmented, prothorax almost entirely covered with pigmentation 7
- Thoracic pigmentation absent, or limited to lateral spots; if on dorsum confined to transverse bars near anterior margins of segments 10

⁹ Species not included in key: *alexanderi*, *arboricola*, *baueri*, *bermudensis*, *biguttatus*, *denticulatus*, *dickei*, *downesi*, *furenoides*, *loisae*, *niger*, *piliferus*, *pseudopiliferus*, *scanloni*, *sphagnumensis*, *spinusus*, *stilobezzioides*, *testudinalis*, *travisi*, *utorovana*.

7. —With distinct pigmented lateral bodies on meso- and metathoracic segments in addition to pigmentation on dorsum 8
 —Lateral pigmented bodies absent 9
8. —All thoracic segments with dorsum almost entirely pigmented *crepuscularis*
wisconsinensis
 —Meso- and metathoracic segments with pigmentation lighter and confined to anterior half or less *hollensis*
9. —Pigmentation arranged in a distinct and definite pattern on dorsum of pro- and mesothorax (figure 283), pigment reddish-purple *haematopotus*
 —Pigmentation diffuse over entire dorsum, especially on pro- and mesothorax (figure 281), pigment dirty brownish *furens*
10. —Venter of head capsule with three longitudinal sclerotized brown lines running the length of the head capsule; thoracic markings may be very faint *melleus*
 —Venter of head capsule without sclerotized brown lines 11
11. —Thorax with lateral pigmented bodies at midlength on each segment; eyes small, consisting of a single spot on each side 12
 —Prothorax with lateral pigmented bodies near anterior margin present or absent, those on meso- and metathorax at midlength; eyes larger consisting of two spots on each side 14
12. —Dorsal head length less than 120 microns *chiopterus*
 —Dorsal head length more than 125 microns 13
13. —Dorsal head length 156-175 microns *sanguisuga*
 —Dorsal head length 125-147 microns *obsoletus*
14. —A small glistening white larva, frontoclypeus 129-146 microns in length; lateral pigmented spots on meso- and metathorax, faint or absent, none elsewhere *stellifer*
 —Larger larvae, frontoclypeus more than 180 microns long; lateral pigmented spots on meso- and metathorax distinct, transverse

Descriptions of Species

Culicoides alexanderi Wirth & Hubert

Figures 27, 66, 103, 140

Culicoides alexanderi Wirth & Hubert, 1962:190, figure 6a-d, 14 (♀).

FEMALE. Eyes narrowly separated. Proboscis short, P/H ratio 0.64 (0.58-0.69). Mandible with 12.8 (11-15) small teeth. Flagellomere length ratios 11/8/8/9/9/9/9/9/-/13/14/16/18/25; AR=1.20 (1.11-1.38); sensillar pattern 3, 5, 7, 9, 13-15, occasionally absent on one or more of these antennomeres. Third segment of maxillary palp moderately swollen, short, L/W ratio 2.49(2.39-2.83), sensory pit shallow with small opening.

Wing length 1.17(1.13-1.26)mm., distinct pale spots in typical *piliferus* group pattern; macrotrichia moderately abundant to abundant. Legs with very faint pale bands; four hind tibial spines with the second longest.

Two very unequal, subelliptical, heavily pigmented spermathecae with a maximum width of 38(33-44) and 57(51-62) microns respectively, neck short parallel sided or absent.

COMMENT. The only dark brown species with eyes narrowly separated.

MALE, PUPA and LARVA. Unknown.

DISTRIBUTION. *Alexanderi* was described by Wirth and Hubert (1962) who recorded it from Conn., Ky., Mass., Mich., Que., and Tenn.

New York State Records (first records from State)

Cattaraugus County, Allegany State Park, May 28-June 3, 1963, 3 ♂♂ and 1 ♀ in LT, coll. WWW; same location and dates, stream margin, 1 ♀, coll. WWW.

Chautauqua County, Ivory, grassy puddle, May 31, 1963, 6 ♀ ♀, coll. WWW.

St. Lawrence County, Cranberry Lake, June 24-26, 1963, 1 ♀ in LT, coll. WWW.

Tompkins County, Ithaca, Ellis Hollow, June 19, 1963, 1 ♀ in LT, coll. C. O. Berg.

Wyoming County, Portageville, Genessee River, June 13, 1963, 2 ♀ ♀, coll. WWW.

BIOLOGY. *Seasonal distribution.* Adults have been collected only in the spring and early summer, from April into June.

Breeding sites. Unknown.

Feeding habits. There is one record of this species biting man (Wirth & Hubert, 1962), otherwise unknown.

Culicoides arboricola Root & Hoffman
Figures 28, 67, 104, 141, 188, 217, 245

Culicoides arboricola Root & Hoffman: Fox, 1942: 416, figures 16, 17 (pupa); Foot & Pratt, 1954: 15-16, figures 30, 56, 77, 123 (♂, ♀); Jones & Wirth, 1958: 84-86 (♀).

FEMALE. Eyes narrowly separated. Proboscis very long, P/H ratio 1.00-1.02 ($n=2$). Mandible with 17(16-18, $n=2$) well developed teeth. Flagellomere length ratios 14/10/11/11/11/12/12/11/-/23/24/24/26/33 ($n=2$), $AR=1.35-1.45(n=2)$; sensillar pattern 3, 5, 7, 9, 11-15 ($n=2$). Third segment of maxillary palp slightly swollen, L/W ratio 2.94-3.13($n=2$), sensory pit moderately deep with large opening.

Wing length 1.16-1.29($n=2$)mm., with distinct pale spots as indicated in figure 28, resembling *guttipennis* but differs in having at least the distal half of vein Cu_1 in a pale spot; macrotrichia abundant. Legs with distinct pale bands near apex of femur and near base of tibia, "knees" dark; five hind tibial spines with 1 and 2 subequal and longer than the rest.

Two subequal, subelliptical, slightly asymmetrical, heavily pigmented spermathecae with a maximum width of 39-42($n=2$) and 45-47($n=2$) microns respectively; neck blunt tapering.

COMMENT. Females of this species closely resemble *guttipennis*, differing mainly in having fewer mandibular teeth, a shallower sensory pit on the third segment of the maxillary palp with a shallower sensory pit, and a somewhat shorter wing with slightly different markings.

MALE TERMINALIA. One specimen seen. Ninth tergum with stout apicolateral processes which would barely touch if directed medially; median notch narrow V-shaped; ninth sternum with a broad deep concave posterior emargination, membrane not spiculate. Basistyle with ventral root long, strongly tapered; subequal in length to slightly stouter parallel-sided dorsal root.

Paramere tapering gradually to a fine, bare point, curved outwardly, ventrally, and posteriorly in a semicircle; paramere becoming gradually more swollen toward base, narrowly joined to anteriorly directed accessory process. Aedeagus with a long, very slender median posterior process which tapers to a fine blunt point, lateral arms moderately long, arcuate.

PUPA. Agreeing with the description of *guttipennis* except respiratory horn longer and more slender, widest near the base, L/W ratio 6.1(5.6-6.4, n=3) with 11 apical (10-12, n=3) and 2.7(2-3, n=3) lateral spiracular openings. Abdomen including dorsum of last segment largely covered with fine spines which are not flattened and confluent as in *guttipennis*. Very closely resembles *villosipennis* (see p. 117).

LARVA. None seen.

DISTRIBUTION. *Arboricola* is a common treehole breeding species in the southeastern states but occurs as far north as Wisconsin and New York State. It has been collected in Ala., Fla., Ga., Ill., La., Md., Miss., N. Y., Okla., Tenn., Tex., and Wis.

New York State Records (first records from State)

Albany County, East Berne, Jamnback's, July 27, 1963, 1 ♀ from LT on top of chicken house, coll. HAJ.

BIOLOGY. *Seasonal distribution.* *Arboricola* probably breeds continuously in warm weather in the south. Snow *et al.* (1957) collected adults from April through September in the Tennessee Valley area. Wirth & Bottimer (1956) collected adults from March into November in Texas and Beck (1958) collected adults from February into December in Florida.

Breeding sites. This species has been found breeding only in moist

or wet sites in treeholes or hollow stumps (Foote & Pratt, 1954 and many others).

Feeding habits. *Arboricola* has not been recorded biting man. Snow *et al.* (1957) collected engorged specimens in a chicken shed and Wirth & Bottimer (1956) noted its abundance in a chicken yard suggesting that it might be ornithophilic. Its well developed proboscis, mandibular teeth and tormae indicate that it is haematophagous. The presence of sensilla on most of the antennomeres also suggests that it is ornithophilic.

Culicoides baueri Hoffman

Figures 29, 68, 105, 142, 189, 218, 246

Culicoides baueri Hoffman: Jones, 1961a: 741, figures 54-57 (pupa); Foote & Pratt, 1954: 16, figures 23, 46, 89, 104 (♂, ♀).

FEMALE. Eyes narrowly separated. Proboscis of intermediate length, P/H ratio 0.68-0.73(n=2). Mandible with 12(n=1) well developed teeth. Flagellomeres length ratios 14/9/9/9/9/9/10/-/15/16/17/18/28(n=2); sensillar pattern 3-10. Third segment of maxillary palp greatly swollen, L/W ratio 2.00(n=2), sensory pit deep with large opening.

Wing length 1.20-1.22(n=2)mm., with distinct pale spots as indicated in figure 29; pale spot over r-m cross-vein not extending basad of vein; macrotrichia moderately abundant. Legs with distinct pale bands near apex of femur and base of tibia, "knees" dark; 4 hind tibial spines with the first longest.

Two subequal subelliptical spermathecae, crumpled and lightly pigmented in both of the specimens examined, estimated maximum width about 48 microns; neck long parallel sided.

COMMENT. *Baueri* and *stilobezzioides* are the only New York State species with sensilla present only on antennomeres 3-10. *Baueri* and *haematopotus* are the only species with a distinct pale spot over the r-m cross-vein which does not extend basad of this vein. In *baueri* there is a small distinct light spot near the center of cell R₅, while in *haematopotus*, this spot is found at the tip of cell R₅.

MALE TERMINALIA. Two specimens seen. Ninth tergum with moderately stout apicolateral processes which would not touch if

directed medially; median notch weakly indicated or apparently absent; ninth sternum with broad, shallow concave posterior emargination, membrane not spiculate. Basistyle with "boat-hook" shape; ventral root long, stout parallel sides.

Paramere gradually tapering to a fine point, with a row of spines near tip, curved outwardly, ventrally and anteriorly in a semicircle; paramere slender, except at base, which is slightly enlarged. Aedeagus with moderately long, slightly tapered median posterior process, truncate and ridged at tip; with two small lateral posterior processes, one on either side of median posterior process, lateral arms long, basal flanges absent.

COMMENT. This species and *haematopotus* are the only two occurring in New York State with lateral posterior processes on the aedeagus.

PUPA. Respiratory horn light brown, concolorous or slightly paler than rest of pupal pelt except slightly darkened apically, with 7(6-8) apical and 3 lateral ($n=4$) spiracular openings on pronounced protuberances, with transverse convolutions just distad of midlength where slightly paler, no spines; horn slender, widest near base, L/W ratio 9.6(8.1-11.7). Operculum with long spines abundant over most of surface; *am* setae about one-third as long as maximum width of operculum. The *d* tubercles 1-3 about equidistant, in line, setae 1 and 2 moderately long, not overlapping; thoracic surface between and adjacent to tubercles papillate. Abdomen with fine spines confined mostly to anterior margins of segments, sparse elsewhere. The *lmp* tubercles rounded or with blunt points, with a subapical seta. Last segment with a patch of spines on disc; caudal apicolateral processes with a few fine spines, apical half darkened, directed posteriorly at an angle of 20 to 30 degrees to the longitudinal axis of the body.

LARVA. None seen.

DISTRIBUTION. A widespread sometimes fairly abundant species that has been collected in Calif., Col., Ga., Md., N. Y., Tenn., Tex., and Wis., as well as in Mexico and parts of South America.

New York State Records (first records from State)

Cattaraugus County, Allegany State Park, stream margin, June 3, 1963, reared 3 ♂♂ and 5 ♀♀, coll. WWW.

Chautauqua County, Ivory, grassy puddle, May 31, 1963, reared 1 ♂ and 1 ♀, coll. WWW.

Schuyler County, Mecklenburg, creek margin, June 17, 1963, reared 1 ♀, coll. WWW.

Tompkins County, McLean Reserve, Sphaerium Brook, creek margin, June 18, 1963, reared 2 ♂♂ and 1 ♀, coll. WWW.

BIOLOGY. *Seasonal distribution.* *Baueri* adults have been collected throughout the summer from April into September, but appear to be most abundant in May and June (Hoffman, 1925; James, 1943; Jones, 1961a; Pickard & Snow, 1955; Snow *et al.*, 1957; Williams, 1955a).

Breeding sites. Our rearing records and those of other workers (Jones, 1961a and Williams, 1955a) indicate that stream and spring margins are a favored breeding habitat.

Feeding habits. Unknown. The well developed mandibular dentition, strong tormae, and sensorial pattern indicate that it is probably ornithophilic.

Culicoides bermudensis Williams

Figures 30, 69, 106, 143, 190, 219, 247

Culicoides bermudensis Williams, 1956a: 298-299, figures 1-3 (♀); Beck, 1956: 134-135, figures 1a, b (♂).

FEMALE. Eyes widely separated. Proboscis of intermediate length, P/H ratio 0.67(0.59-0.71, n=4). Mandible with 7(6-8) weakly developed teeth. Flagellomere length ratios 14/9/9/9/9/8/9/9/-/12/13/15/18/22, AR=1.12(1.06-1.20); sensillar pattern 3, 13-14 on 3 specimens from Florida and Bermuda and 3, 11-14 on 2 specimens from New York State. Labial palps slightly swollen distally. Third segment of maxillary palp greatly swollen, L/W ratio 2.05 (1.76-2.36, n=4), sensory pit quite variable with shallow to deep pit and moderate to large opening.

Wing length 0.97(0.93-1.02, n=4)mm., with faint to distinct pale spots as indicated in figure 30, resembling *hollensis* but with smaller pale spot at tip of cell R₅ and larger pale spot in anal cell; macrotrichia sparse, scattered and short.

Legs lacking pale bands; usually 4 hind tibial spines with the first longest. (One of five specimens had 5 tibial spines with the second one longest.)

One unusually large spermatheca present, maximum width about 123 microns (119-136 microns, $n=4$). The spermatheca of all five slide-mounted specimens examined was very lightly pigmented and slightly collapsed; one so much so that it could not be measured with reasonable accuracy. As is typical for *Culicoides* with one spermatheca the rudimentary spermatheca and sclerotized ring were absent.

MALE TERMINALIA. We have not seen the male of this species, the following description is adapted from Beck (1956). Ninth tergum with moderately stout apicolateral processes which would not touch if directed medially; median notch broadly V-shaped; ninth sternite with deep V-shaped posterior emargination, membrane spiculate. Basistyle with ventral root indicated by a slight projection; dorsal root short tapering.

Paramere tapering to a fine bare point, gradually becoming more swollen posteriorly, with a subtriangular anteriorly directed accessory process at base. Aedeagus with a broad, apically rounded median posterior process, lateral arms short, with a short flange at base.

PUPA. (Two Long Island specimens) Respiratory horn pale except darkened slightly apically with 5 apical and 2-3 lateral spiracular openings; not narrowed or convoluted near the middle, surface smooth with only a few very inconspicuous scattered small spines. Operculum with long stout spines moderately abundant and confined mainly to the disc, but extending further posteriorly along the lateral margins; *am* setae short, less than one-third as long as maximum width of operculum. The *d* tubercles 1-3 in line, equidistant, setae 1 and 2 subequal, moderately long; area between *d* tubercles with a few fine papillae.

Abdomen with fine spines confined mostly to anterior margins of segments. The *lpm* tubercles rounded or weakly ridged. Last segment without patch of spines on disc; caudal apicolateral processes with small spines present and apical quarter darkened, directed posteriorly at about a 45 degree angle to longitudinal axis of body.

FOURTH INSTAR LARVA. One reared pelt and head capsule from Long Island examined. Frontoclypeus 91 microns long; comb with 8-9 teeth on each half; total comb width 38 microns.

DISTRIBUTION. Since the known distribution of *bermudensis* was the Bermudas, coastal Florida, and Texas, its occurrence in New York State is somewhat surprising.

New York State Records (first records from State)

Suffolk County, Westhampton Beach, Dune Road, May 3, 1965—2, a Berlese funnel sample taken in salt marsh sod beneath *Spartina alterniflora*, reared larva May 3, pupated May 7, ♀ emerged May 10; same sample, reared pupa collected May 7, ♀ emerged May 11, coll. HAJ.

BIOLOGY. *Seasonal distribution.* Williams (1956b) collected *bermudensis* in large numbers in late June in Bermuda. Jones & Wirth (1958) in April, May, and August in Texas. Beck (1958) recorded peak abundance in August in Florida and noted that it was only rarely present earlier in the spring and summer.

Breeding sites. *Bermudensis* breeds in saline habitats. Williams (1957) collected adults from recovery cages placed over a wide variety of plants where the salinity ranged from 1.2 to 15 parts per thousand. In Texas, it was reared from specimens collected at the margins of salt water pools and from salt water well overflow areas (Wirth & Jones, 1958; Jones 1961b). On Long Island, it was taken in a salt marsh as noted above.

Feeding habits. Unknown. The relatively short proboscis and reduced mandibular dentition suggest that it may not be haematophagous; however, the tormae, which are reduced in most non-blood-sucking species are quite well developed. Williams (1961) reported that *bermudensis* is autogenous and parthenogenetic in Bermuda.

Culicoides bickleyi Wirth & Hubert

Figures 31, 70, 107, 144, 177, 186, 191, 220, 248, 277

Culicoides bickleyi Wirth & Hubert, 1962: 188-189, figures 4a-g, 13 (♂, ♀).

FEMALE. Eyes narrowly to moderately separated. Proboscis short, P/H ratio 0.56(0.53-0.62). Mandible with 13(12-14) well developed teeth. Flagellomere length ratios 13/8/8/9/9/9/9/9/-/14/14/17/-/19/27, AR=1.25(1.20-1.35); sensillar pattern 3, (5), (7), (9), 13-15. Third segment of maxillary palp short, moderately swollen, L/W ratio 2.06(1.87-2.18), sensory pit shallow with moderately large opening.

Wing length 1.13(0.99-1.22)mm., with well-marked typical *piliferus* pattern; macrotrichia moderately abundant. Legs with faint pale bands; 4-5 hind tibial spines with the second usually longest.

Two well-pigmented, very unequal, long, subelliptical spermathecae, with a maximum width of 49(41-55) and 36(30-39) microns respectively, neck absent or very short parallel sided.

MALE. Closely resembles *piliferus*.

PUPA. Agreeing with the description of *jamnbacki*. The only difference noted was in the length of *d* setae 1 and 2 which appear to be slightly shorter in *bicklei*.

FOURTH INSTAR LARVA. Frontoclypeus 197(187-211, $n=3$) microns long. Comb with 7($n=2$) unequal teeth on each half; total comb width 29($n=2$) microns; head capsule brownish yellow, frontoclypeus slightly darker brown.

Thorax with distinct dark markings resembling *jamnbacki* except that the lateral markings of the prothorax are longer.

DISTRIBUTION. *Bicklei* is widely distributed in eastern North America. It has been recorded from Conn., Fla., Md., Mass., Mich., N. Y., Ont., Que., S. C., Va., W. Va., and Wis. (Wirth & Hubert, 1962).

New York State Records

Albany County, E. Berne, Jamnback's, June 14, 1963, 1 ♀ in LT; same location June 20, 1963, 1 ♀ in LT; same location, swamp margin, May 3, 1963, reared 3 larvae, pupated May 5, 6, 8; 1 ♂ emerged May 10, 1 ♀ emerged May 11, coll. HAJ.

Hamilton County, Blue Mountain L., Stanton place extreme collection dates June 7-July 11, 14 ♀ ♀ in LT; Sphagnum Bog, June 12, 1962, 1 ♀ in LT; same location June 20, 1961, 1 ♀ in LT; Callahan's place, June 30, 1959, 1 ♀ in LT; Rte. 28N, by pole 309, May 17, 1960-17, reared larva pupated May 22, ♀ emerged May 28; Pole X, May 9, 1960-12, reared larva, pupated May 13, ♀ emerged May 19; same location, May 6, 1960-12, reared larvae, pupated May 10, 12; ♂ emerged May 17, ♀ emerged May 18, coll. HAJ.

Lewis County, Watson, Pine Grove, June 22, 1963, 2 ♂ ♂ and 3 ♀ ♀ in LT, coll. WWW.

Suffolk County, Quogue, margin of stream crossing Rte. 27, April 29, 1957-2, 1 ♀ in Berlese funnel sample, coll. HAJ; North Sea, Big Fresh Pond Outlet, June 12, 1963, 1 ♀ in LT, coll. R. Means.

Tompkins County, Ithaca, Ellis Hollow, June 19, 1963, 4 ♀ ♀ in LT, coll. C. O. Berg.

Washington County, Cambridge, Fish hatchery, July 1-5, 1963, 3 ♀ ♀ in LT, coll. HAJ.

BIOLOGY. *Seasonal distribution.* *Bickleyi* is an early spring species with adults most abundant in June in the northeastern states and as early as March in the south. It is very probable that the larvae overwinter.

Breeding sites. We have reared *bickleyi* from soft mud taken two inches below the water surface in a small woodland stream, from mixtures of decaying hay, grass roots, and humus at two swamp sites, and from thick sphagnum on the margins of a swamp.

Feeding habits. Although this species has a rather short proboscis, the mouthparts are well developed. The feeding habits are unknown, except for two records of its biting man (Wirth & Hubert, 1962).

Culicoides biguttatus (Coquillett)

Figures 32, 71, 108, 145, 178, 192, 221, 249

Culicoides biguttatus (Coq.): Thomsen, 1937: 70, figures 90, 94, 126 (pupa); Foote & Pratt, 1954: 16-17, figures 7, 42, 72, 118 (♂, ♀).

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.86 (0.80-0.91). Mandible with 15.3(15-17, n=9) well developed teeth. Flagellomere length ratios 14/10/10/11/12/11/11/12/-/17/17/19/20/28, AR=1.11(1.08-1.19); sensillar pattern 3, (5), 7, 9, (10), 11-15. Third segment of maxillary palp slightly to moderately swollen, L/W ratio 2.76(2.53-3.14), sensory pit shallow with small opening.

Wing length 1.30(1.25-1.38)mm., with only two pale spots, one just beyond the second radial cell and one over the r-m cross-vein; macrotrichia abundant. Legs with faint pale bands; with 4 hind tibial spines, the second one longest.

Two subequal subelliptical, heavily pigmented spermathecae with a maximum width of 43(42-45) and 47(44-50) microns respectively; neck blunt tapering.

MALE TERMINALIA. Ninth tergum with stout apicolateral processes which would not touch if directed medially; median notch broad and deep; ninth sternum with a broad, deep concave posterior emargination, membrane spiculate. Basistyle with ventral root long slender, slightly longer than the stouter, parallel-sided dorsal root.

Paramere tapering rapidly to a relatively blunt bare tip, curved outwardly and sometimes slightly posteriorly; paramere gradually becoming more swollen toward base where it is narrowly joined to an anteriorly directed accessory process. Aedeagus with a broad strongly tapering median posterior process which is rounded apically but often bent ventrally near tip so that it appears truncate; lateral arms short, with a short flange at base.

PUPA. Respiratory horn uniformly brown, darker than rest of pupa, with 5.2(4-6) apical and 2.4(2-3) lateral spiracular openings; not narrowed or convoluted near the middle, with abundant scale-like spines on median two-thirds, widest near base, L/W ratio 5.6(5.1-6.4). Operculum with short spines over most of disc, extending further back along the lateral margins; *am* setae moderately long, stout, less than one-half as long as maximum width of operculum. The *d* tubercles in line, equidistant, setae 1 and 2 subequal, short; thoracic surface between and adjacent to tubercles with fine papillae.

Abdomen with fine spines along anterior margins of segments and sparsely over rest of segments. The *lpm* tubercles rounded or weakly ridged, occasionally weakly bifid. Last segment with a patch of spines on disc; caudal apicolateral processes with spines, apical quarter darkened, directed posteriorly about parallel to longitudinal axis of the body.

FOURTH INSTAR LARVA. Two head capsules examined. Frontoclypeus 187-211 microns long. Comb with 7-9 teeth on each half; total comb with 32-33 microns; head capsule yellow.

DISTRIBUTION. *Biguttatus* is a common and widely distributed species east of the Mississippi River and has been collected irregularly further west. It has been recorded from Ala., B. C., Colo., Conn., Fla., Ga., Ill., Kans., Md., Mass., Mich., Mont., N. J., N. Y., Ohio, Ont., Pa., R. I., Tenn., Tex., Va., Vt., and Wis. Records of its occurrence in Alaska (Jenkins, 1948; Sailer *et al.*, 1949) are erroneous (Wirth, 1951a; Sailer *et al.*, 1956).

In New York State, it has been collected from Albany, Cattaraugus, Genesee, Essex, Hamilton, Lewis, Livingston, Nassau, Niagara, Orleans, Seneca, Steuben, Suffolk, Tompkins, Ulster, and Washington Counties and probably occurs throughout the State.

BIOLOGY. *Seasonal distribution.* Adults of this species have been collected from spring to fall but not in large numbers. In New York State they have been collected from May 26 through October 5 and were most common from early June through August. In the Tennessee Valley area, Snow *et al.* (1957) collected adults from April 9 to October 2 in light traps. Other workers, collecting for shorter periods, have reported substantially similar results.

Breeding sites. *Biguttatus* has been reared from larvae or pupae collected from a wide variety of habitats. These include the margins of lakes, pools, and streams as well as moist leaf depressions. The substrate is usually moist sand, mud, or decaying leaves (Murray, 1957; Snow *et al.*, 1957; Wirth, 1951b; Williams, 1955b). We have reared 13 ♂♂ and 12 ♀♀ from six sites. These include a semipermanent woodland pool, a cedar bog, and 4 grassy marsh sites. The substrates have included spruce and hemlock with black mud beneath, and "grass," "grass" roots, humus, and clayey soil. *Biguttatus* larvae probably inhabit the "generalized" *Culicoides* breeding environment discussed under larval breeding habitats.

Feeding habits. *Biguttatus* rarely bites man. There is a single specimen in the NYSM collection labelled biting man, from Allegany State Park (June 25, 1957, coll. John Wilcox). Metcalf's (1932) records of this species as the chief pest of man in the Adirondack Mountains are erroneous (Jamnback, 1961). Elsewhere biting records of Coher *et al.*, 1955; Pickard & Snow, 1955; Williams, 1955b; Murray, 1957 and Jones (in Snow *et al.*, 1957) indicate that it bites man rarely, although Malloch (1915b) collected up to 13 specimens biting man in a single day.

Hoffman (1925) stated that it may be "bad" on cows, while Pickard & Snow (1955) noted it feeding heavily on horses. Downes (1958) stated that they attack horse, cattle, and domestic fowl. Osgoode (*in* Downes, 1958), Jellison & Philip (1933), and Judd (1957) reported it from birds' nests, and Pickard & Snow (1955) from chicken houses.

The limited data available suggests that it is primarily a pest of the larger mammals or birds. Earlier records should be considered with caution, since *biguttatus* can easily be mistaken for other species with wings having only two pale spots.

Culicoides chiopterus (Meigen) Figures 33, 72, 109, 146, 184, 193, 222, 278

Culicoides chiopterus (Meigen): Jamnback & Wirth, 1963: 187-188, figures 5, 8, 12, 16, 20, 24, 28, 30, 35, 37, 39, 41 (♂, ♀ pupa, larva).

FEMALE. Eyes contiguous; without superior transverse suture. Proboscis short, P/H ratio 0.64(0.59-0.74). Mandible, with 7.8(6-9)

well developed teeth. Flagellomere length ratios 11/6/7/7/7/7/8/-/12/13/14/15/23, AR=1.17(1.13-1.20); sensillar pattern 3, 11-15. Third segment of maxillary palp short, moderately swollen, L/W ratio 2.14 (1.67-2.57), sensory pit shallow, with small to moderately large opening.

Wing length 0.91(0.87-0.98)mm.; with distal half of second radial cell included in light spot and other light spots faint, as shown in figure 33; macrotrichia sparse and largely confined to wing apex; vein M_{3+4} usually with fewer than 8 macrotrichia and cell M_4 usually without macrotrichia, excluding those bordering the margin. Legs without distinct pale bands; with 5 hind tibial spines, the first longest. Two subequal, lightly to moderately pigmented, subelliptical spermathecae with a maximum width of 35(32-38) and 33(32-35) microns respectively; neck short to very short, slightly tapered sub-parallel.

COMMENT. This species can be distinguished from *obsoletus* and *sanguisuga* by its smaller size, smaller proboscis, fewer mandibular teeth, and fainter wing markings.

MALE TERMINALIA. Ninth tergum with short but stout apico-lateral processes which would not touch if directed medially; median notch barely indicated by a slight depression; ninth sternum with a narrow deep concave posterior emargination, membrane not spiculate. Basistyle with ventral root long slender; dorsal root shorter, stout basally, tapering, distally slender and parallel sided.

Paramere gradually tapering to a fine, bare, distal point, curved inwardly and slightly posteriorly; paramere becoming gradually more swollen toward base with a stout tapering outwardly directed basal flange. Aedeagus with a moderately long, tapering, blunt pointed median posterior process and long lateral arms; with a sclerotized membrane extending transversely between the arms; lacking a more heavily sclerotized transverse basal bar such as occurs in *venustus*; arms slightly curved outwards at base.

PUPA. Respiratory horn uniformly medium to dark brown, darker than rest of pelt, with 4.6(3-5) apical and 4.2(3-5) lateral spiracular openings; horn without spines, slightly narrowed medially, widest near base, L/W ratio 4.9(4.6-5.0). Operculum with very long hair-like spines confined to lateral margins and disc, as indicated in figure 222; *am* seta length, *d* setae and tubercles and abdomen as described for *sanguisuga*.

COMMENT. Can be distinguished from *sanguisuga* and *obsoletus* by the dark respiratory horn, more spinules on the lateral margin of the operculum 13.6(11-16, n=17), and the relatively longer *ad* setae, the longer of which is longer than the respiratory horn.

FOURTH INSTAR LARVA. Dorsal head length 118(115-119, $n=10$) microns. Comb with 8.8(8-9) teeth on each half; total comb width 19(18-20) microns; head capsule pale yellow.

Thoracic pigmentation as in *sanguisuga* and *obsoletus*.

COMMENT. *Chiopterus* larvae can be distinguished from *sanguisuga* and *obsoletus* by their shorter heads.

DISTRIBUTION. Alaska, B. C., Conn., Md., Mich., N. Y., Ont., Que., Va., and Wash. This species and *obsoletus* are the only two found in both Eurasia and North America (Jamnback & Wirth, 1963). The records are spotty. Females probably have often been confused with *obsoletus*.

Differences in the P/H ratio and number of mandibular teeth suggest that "*chiopterus*" from the northeastern United States may not be conspecific with European *chiopterus* (see Jamnback & Wirth, 1963). In New York State, *chiopterus* has been recorded only from Hamilton and Essex Counties, but probably has a much wider distribution.

BIOLOGY. *Seasonal distribution*. In the Adirondack Mountain area of New York, adults were reared or collected in light traps between May 23 and October 10.

Breeding sites. In our studies, *chiopterus* was taken from moist straw and moist polluted soil mixed with chicken manure. Kettle & Lawson (1952) collected the immature stages regularly from pats of cow dung, in Scotland.

Feeding habits. *Chiopterus* has not been collected attacking man in North America. However, Remm (1956) has stated that it may be an important bloodsucking pest of man in Estonia, especially in the spring and fall.

Culicoides crepuscularis Malloch

Figures 34, 65, 73, 110, 147, 194, 223, 250, 271, 279

Culicoides crepuscularis Malloch: Thomsen, 1937: 70, figures 91, 127 (pupa); Fox, 1942: 416, figures 16, 17 (pupa); Foote & Pratt, 1954: 19-20, figures 14, 47, 64, 73, 98 (δ , ♀).

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.80, (0.70-0.89). Mandible with 13.6(13-15) well developed teeth. Flagellomere length ratios 14/9/9/9/9/9/9/10/-/18/19/21/22/29, AR=1.38

(1.28-1.44); sensilla present on all flagellomeres. Third segment of maxillary palps greatly swollen, L/W ratio 2.21(2.00-2.59), with large, deep sensory pit.

Wing length 1.30(1.20-1.37)mm., light brown with many light spots that occur mainly in cells rather than on veins (figure 34), macrotrichia abundant. Legs indistinctly banded; 4 hind tibial spines with the first longest.

One large lightly pigmented, long subelliptical spermatheca 66 (62-72) microns maximum width, neck very short parallel sided or absent.

MALE TERMINALIA. Ninth tergum with slender apicolateral processes which would not touch if directed medially; median notch broad and distinct; ninth sternum with a broad but shallow concave posterior emargination, membrane spiculate. Basistyle with ventral root indicated by slight protuberance; dorsal root moderately long, tapering.

Paramere gradually tapering to a fine bare point, curving inwardly and then outwardly toward tips so that the two parameres may cross; paramere slightly swollen just basad of midlength, base narrowly joined to anteriorly directed accessory process. Aedeagus with a moderately long, tapering, apically rounded median posterior process and long arcuate lateral arms, each with a flange at base.

COMMENT. Closely resembles *hollensis* and *wisconsinensis*, see descriptions of these species.

PUPA. Respiratory horn light brown, concolorous with rest of pupal pelt except much darker apically, with 6.8(6-8) apical and 3.2(3-4) lateral spiracular openings; narrowed near middle but without transverse convolutions, with well developed transverse scale-like spines on median two-thirds, widest near base, L/W ratio 6.7(6.2-7.2). Operculum covered densely with short stout spines; *am* setae short and stout, less than three-tenths as long as maximum width of operculum. The *d* tubercles in line, about equidistant, *d* setae 1 and 2 moderately long, 1 slightly longer than 2, not overlapping; thoracic surface between and adjacent to tubercles rough, covered with numerous papillae.

Abdomen with fine spines confined mostly to anterior margins of segments, sparse elsewhere. The *lpm* tubercles rounded, some weakly pointed or bifid. Last segment with a patch of spines on disc; caudal apicolateral processes with spines present, distal third dark brown, directed posteriorly at an angle of 30 degrees or less to the longitudinal axis of the body.

FOURTH INSTAR LARVA. Dorsal head length 172(150-194) microns. Comb with 8(7-9, n=3) unequal teeth on each half; total

comb width 26(24-29, $n=3$) microns; head capsule pale yellow.

Dorsum of all thoracic segments lightly and rather uniformly pigmented reddish-brown; meso- and metathorax with more heavily pigmented round lateral spots at about midlength of each segment.

DISTRIBUTION. *Crepuscularis* is one of the most widely distributed of the North American *Culicoides*. It has been recorded from Canada to Mexico and from Maine to California as well as from Bermuda. It has been collected in Ala., Bermuda, B. C., Calif., Colo., Fla., Ga., Ill., Kans., Me., Md., Mass., Mexico, Mich., Minn., Miss., Mont., Neb., N. J., N. Y., N. M., N. C., Okla., Ont., R. I., Sask., S. D., Tenn., Tex., Utah, Vt., Va., and Wis.

New York State Records

Albany County, Altamont, Quay Rd., mossy bank of stream inlet, July 3, 1963—5, reared pupa, ♀ emerged July 11; E. Berne, Jamnback's, June 20-August 20, 1963, 2 ♂♂ and 8 ♀♀ in LT; same location, August 26, 1962, 3 ♀♀ in LT; New Salem, grassy stream margin, June 29, 1963—1, reared larva, pupated July 2, ♀ emerged July 5, coll. HAJ.

Chautauqua County, Sinclairville, muddy brook, May 31, 1963, 1 ♂; Ivory, grassy puddle, May 31, 1963, reared 3 ♂♂ and 8 ♀♀, coll. WWW.

Genesee County, Batavia, Foote & Pratt (1954); Bergen Swamp, Cedar bog, June 14, 1963, reared 1 ♂ and 2 ♀♀, coll. WWW.

Hamilton County, Blue Mountain L., Eagle Nest, August 25-31, 1959, 1 ♀ in LT; same location September 22, 1959, 1 ♂ and 1 ♀ in LT, coll. HAJ.

Jefferson County, Watertown, Rte. 12, stream by Reasoner's Garage, May 20, 1963—1, 2, reared 2 pupae, 2 ♀♀ emerged May 23, coll. HAJ.

Lewis County, Port Leyden, swamp, grass roots and humus, July 4, 1959—3, 4 pupae collected from Berlese funnel sample, 1 pupa on July 8, ♀ emerged July 12, 1 pupa on July 9, ♂ emerged July 14, 2 pupae on July 10, 2 ♂♂ emerged July 13, coll. M. McFadden.

St. Lawrence County, Canton, Rte. 68, 4 miles nw of city, cattle hoofprints containing water, July 15, 1963—4, reared larva, pupated July 24, ♂ emerged July 27; same site July 15, 1963—3, reared pupa, ♀ emerged July 19; same collection, pupa and associated ♂ found July 17; Massena, Rte. 37, near school, grass and mud, marshy ditch, July 16, 1963—8, reared larva, pupated July 19, ♂ emerged July 24,

coll. HAJ; Cranberry Lake, swamp, June 25, 1963, reared 3 ♂♂ and 4 ♀♀, coll. WWW.

Seneca County, Montezuma Swamp, lagoon margin, June 11, 1963, reared 2 larvae, pupated June 15, June 16, 2 ♂♂ emerged June 23, coll. HAJ.

Suffolk County, Speonk, Wilcox Duck Farm, August 14, 1962, 1 ♀ in LT, coll. R. Means; Mastic Beach, July 2-5/53, 1 ♀ in LT; Timber Point, July 16, 1953, 1 ♂ in LT, coll. HAJ.

Tompkins County, Ithaca, Ellis Hollow, June 19, 1963, 1 ♂ and 1 ♀ in LT, coll. C. O. Berg; Cornell University cow pasture, cattle hoofprints containing water, July 9, 1963—3, reared 3 larvae, pupated July 11-14, 1 ♂ and 1 ♀ emerged July 15-17, coll. HAJ.

Wyoming County, Warsaw, Oatka Creek margin, June 11, 1963, 1 ♀ coll. WWW.

BIOLOGY. *Seasonal distribution.* *Crepuscularis* adults are present from spring to late fall in much of the United States. Beck (1958) recorded peak populations in March in Florida while Wirth & Bottimer (1956) noted increased populations both in the spring and fall in Texas. Snow *et al.* (1957) recorded a peak in early June in Tennessee and Lewis (1959) recorded peak numbers in late July and again in early September in Connecticut. Collection records from New York suggest that *crepuscularis* produces more than one generation per year with adult populations highest in mid to late summer. They were much less abundant in the colder Adirondack Mountain region than in warmer portions of the State.

Breeding sites. This species has been found breeding in a wide variety of habitats ranging from highly saline sites (Williams, 1956, 1957) to fresh water. It has been reared from muddy and sandy pond margins, puddles at water tank and septic tank effluents, and from seepage ditches (Wirth & Bottimer, 1956; Jones, 1959; Snow *et al.*, 1957). In New York we have reared it, along with *venustus*, from cattle hoofprints containing water in marshy meadows, and with *haematopodus* from stream margins, and with *wisconsinensis* from a lagoon margin, as well as from a marshy drainage ditch. The substrate was usually clayey mud with grass roots and some humus. In several cases the larvae were collected from samples taken beneath the water level.

Feeding habits. Bennett (1960) and Fallis & Bennett (1960, 1961a) have shown that *crepuscularis* is ornithophilic and have recorded it feeding on spruce grouse, grouse, crows, owls, flickers, and purple finches. Bennett (1961) used this species along with *sphagnumensis* and *stilobezzioides* in trypanosome transmission tests using robins, ducks, white-throated sparrows, purple finches, grouse, and blue jays

as hosts. Fallis and Bennett (1961b) incriminated *crepuscularis* as an intermediate host of a protozoan (*Haemoproteus*) parasite of crows and purple finches. Robinson (1961) collected a large number of engorged *crepuscularis* females in a trap using a starling as bait and reported on the early development of an avian filarial worm in the midges following feeding on the infected starling. Earlier studies by Williams (1955a) and Snow *et al.* (1955) indicated that *crepuscularis* was more abundant in the trees rather than at ground level suggesting that it was a bird feeder. Other workers have reported it attacking poultry (Hoffman, 1925) or have found it engorged in or near bird nests (Jellison & Philip, 1933; Snow *et al.*, 1957). Although Edmunds & Keener (1954) reported that *crepuscularis* was a serious pest of man in Nebraska, elsewhere it bites man rarely (Snow *et al.*, 1957) or not at all (Downes, 1958), even though it is abundant. It has not been collected annoying or biting man in New York State.

Culicoides denticulatus Wirth & Hubert

Figures 35, 74, 111, 148, 195, 224, 251

Culicoides denticulatus Wirth & Hubert, 1962: 193-195, figures 10, 18 (♂, ♀).

FEMALE. Eyes touching to moderately separated; superior transverse suture present. Proboscis short, P/H ratio 0.65(0.59-0.69). Tip of labrum with an unusual and distinct fleshy tufted distal prolongation. Labial palps slightly swollen. Mandible with 5.0(4-6) poorly developed teeth. Flagellomere length ratios 14/8/9/9/10/10/10/10/-/16/17/19/19/26($n=3$); AR=1.20(1.11-1.30, $n=4$); sensillar pattern 3, 11-15. Third segment of maxillary palp moderately swollen, L/W ratio 2.37(2.13-2.50), sensory pit shallow with large opening.

Wing length 1.28(1.25-1.35)mm., with pale spots very faintly indicated as in figure 35, macrotrichia moderately abundant over most of wing. Legs without distinct pale bands; five hind tibial spines with the second one longest.

Two subequal, lightly to heavily pigmented, subelliptical spermathecae with a maximum width of 53(53-54) and 49(47-51, $n=3$)

microns respectively; one or both with a well developed, moderately long parallel-sided (or slightly tapered) neck.

MALE. Closely resembles *piliferus*.

PUPA. Respiratory horn rather uniformly dark brown, darker than rest of pupa, with 5.3(5-7, n=3) apical and 2.3(2-3, n=3) lateral spiracular openings; median two-thirds with spines moderately abundant; horn slightly swollen, widest near base, L/W ratio 4.7 (4.4-5.0). Operculum largely covered with short papilliform spines; *am* setae long, slender, about half as long as maximum width of operculum. The *d* tubercles 1-3 about in line, nearly equidistant, spines 1 and 2 subequal, moderately long but do not quite overlap; thoracic surface between and adjacent to tubercles strongly papillate.

Abdomen with spines distributed over most of each segment; *lpm* tubercles with a single point or weakly bifid; last segment with spines over most of dorsum; caudal apicolateral processes with scales, darkened at tip, directed posteriorly about parallel to the longitudinal axis of the body.

FOURTH INSTAR LARVA. One flattened head capsule was available for examination. Frontoclypeus 218 microns long. Details of comb not visible on slide.

COMMENT. *Denticulatus*, *loisae*, *spinosus* and *utorwana* are very similar in some stages but can readily be distinguished in others as follows: *spinosus* females have a long proboscis and well developed mandibular dentition without a fleshy distal prolongation of the labrum while the other three species have a short proboscis, poorly developed mandibular dentition, and have a fleshy distal prolongation of the labrum-epipharynx. *Utorwana* females have very unequal spermathecae which lack a distinct neck while the other three species have subequal spermathecae with a moderate to long slightly tapered or parallel-sided neck.

Denticulatus males have the typical *piliferus* group terminalia while those of *spinosus* and *loisae* are of the *biguttatus* group type. The latter two are very similar with parameres terminating distally in four subequal pointed tips. Differences between the male terminalia of *spinosus* and *loisae* are considered on p. 78. The male of *utorwana* is not known.

Denticulatus pupae are distinctive in having uniformly dark brown, heavily scaled respiratory horns, opercula largely covered with short stout papilliform spines, abdominal segments with many spines scattered over surface and *lpm* tubercles with a single apical point. The respiratory horns of the other species are lighter with a darkened apex and fewer spines. *Spinosus* has fewer spines on the

operculum, fewer spines scattered over the abdominal segments and bifid *lpm* tubercles. The operculum of *utowana* is papillate, and it lacks scattered abdominal spines (except near anterior margins), and lacks a dorsal patch of spines on the last abdominal segment; the *lpm* tubercles are rounded. *Loisae* has opercular spines confined almost entirely to the lateral margins with the disc bare, no abdominal spines, excepting those near the anterior segment margins, no patch of spines on the dorsum of the last abdominal segment, and single pointed *lpm* tubercles.

DISTRIBUTION. Northeastern United States and eastern Canada. *Denticulatus* has been recorded from Conn., Md., Mass., Mich., Minn., N. Y., Ont., Que., and Wis. (Wirth & Hubert, 1962).

New York State Records

Cattaraugus County, Allegany State Park, May 28-June 3, 1963, 3 ♀ ♀ in LT, coll. WWW.

Hamilton County, Blue Mountain L., Stanton place, May 30, 1960, 1 ♀ in LT; June 19, 1961, 1 ♀ in LT; Blue Mountain L., Salmon River, pool margin, mud and decayed leaves, May 21, 1958—2, reared pupae and associated ♂ and ♀; same collection, reared larva, pupated May 20, ♂ emerged June 4; same site but grass, sphagnum and leaves, May 21, 1958—4, reared 1 ♂ and 1 ♀ and associated pupa; Salmon River island, leaf depression, May 23, 1960—7B, reared ♀ from Berlese funnel sample; Swamp beyond Salmon River, May 14, 1959—5, reared 2 ♀ ♀ from Berlese funnel sample; Mud Pond Outlet, margin pool edge, soft mud, May 21, 1958—5, reared 1 ♂ and associated pupa; Blue Mountain L., Pole X, open marsh under tree roots, dead sphagnum and soft mud, May 17, 1960—18, reared pupa, ♀ emerged May 20, Long Lake, Fishing Creek, sand and mud margin, May 28, 1958—1 reared 1 ♂, coll. HAJ.

Lewis County, Whetstone Gulf, June 20-23, 1963, 1 ♀ in LT, coll. WWW.

Monroe County, Braddock Bay, near marsh, June 12, 1963, 14 ♂ ♂ and 8 ♀ ♀, coll. WWW.

Tompkins County, Ithaca, May 27, 1925, 1 ♀, coll. W. A. Hoffman (Cornell coll.).

BIOLOGY. In common with most species in the *piliferus* group, this is one of the first *Culicoides* to appear as an adult in the spring.

Breeding sites. *Denticulatus* appears to favor wet sites with soft mud covered with decaying leaves or other humus.

Feeding habits. Unknown. Non-haematophagus.

Culicoides dickei Jones
Figures 36, 75, 112, 149

Culicoides dickei Jones, 1956: 28, 30, figures 1-5 (♂, ♀).

FEMALE. Eyes narrowly separated. Proboscis short, P/H ratio 0.56 (n=1). Mandible with 8(n=1) teeth. Labrum with fleshy distal prolongation, not tufted as in *denticulatus*. Labial palps slightly swollen. Flagellomere length ratios 12/9/8/8/9/9/9/9/-/10/11/11/12/20 (n=1); AR=0.94(n=1); sensillar pattern 3, 8-10. Third segment maxillary palp short, moderately swollen, L/W ratio 2.31(n=1), sensory pit with large opening and shallow pit.

Wing length 1.04(n=1)mm., with distinct pale spots as indicated in figure 36, macrotrichia moderately abundant, similar in general appearance to *furensoides* wing, but macrotrichia not confined mainly to apical half. Legs with distinct pale bands near apex of femur and base of tibia, "knees" dark; five hind tibial spines with the second longest.

Two nearly equal pyriform, moderately pigmented spermathecae with a maximum width of 24 and 26(n=1) microns, respectively; neck long parallel sided.

MALE TERMINALIA. We have not seen males of this species. The following description is adapted from Jones (1956). Ninth tergum with stout apicolateral processes which would barely touch if directed medially; with slight median notch; ninth sternum emarginate appearing cleft in some specimens, membrane not spiculate. Basistyle with ventral root "boat-hook" shaped; dorsal root moderately long and stout, nearly parallel sided.

Paramere with tip bearing a row of spines, curved outwardly, ventrally and posteriorly in a loop; paramere becoming gradually more swollen posteriorly, base slightly swollen. Aedeagus with a moderately long median posterior process, rounded apically, lateral arms moderately long, with a short flange at base.

PUPA and LARVA. Unknown.

DISTRIBUTION. N. Y., Wis.

New York State Records (first records from State)

Lewis County, Brantingham Lake edge, June 22, 1963, ♀ ♀, coll. WWW.

BIOLOGY. *Seasonal distribution.* The type specimens were collected in light traps in Wisconsin between June 13 and July 7.

Breeding sites. Unknown.

Feeding habits. Unknown. Non-haematophagus.

Culicoides downesi Wirth & Hubert
Figures 37, 76, 113, 150

Culicoides downesi Wirth & Hubert, 1962: 186-187, figures 2a-g (♂, ♀).

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.81 (0.76-0.87). Mandible with 16.8(16-19) well developed teeth. Flagellomere length ratios 15/9/10/9/10/10/10/10/-/23/24/25/28/37, AR=1.54(1.48-1.62); sensillar pattern 3, 5, 7, 9, 11-15. Third segment of maxillary palp moderately swollen, L/W ratio 2.58 (2.40-2.74), sensory pit very shallow with large opening.

Wing length 1.51(1.46-1.55), wing with distinct pale spots in typical *piliferus* group pattern; macrotrichia abundant. Legs with faint pale bands; with 4 hind tibial spines, the second one longest.

Two unequal, moderately pigmented, long subelliptical spermathecae with a maximum width of 38(35-41) and 44(41-48) microns respectively; neck very short parallel sided or absent.

COMMENT. This is the largest species in the *piliferus* group.

MALE. Closely resembles *piliferus*.

PUPA and LARVA. Unknown.

DISTRIBUTION. Mich., N.Y., Ont. (Wirth & Hubert, 1962).

New York State Records

Albany County, E. Berne, Jamnback's top of chicken house, June 20, 1963, 1 ♀ in LT, coll. HAJ.

Hamilton County, Blue Mountain L. (Wirth & Hubert, 1962); same location, June 20, 1961, 3 ♀ ♀ in LT, coll. HAJ.

Essex County, (Wirth & Hubert, 1962).

Tompkins County, Ellis Hollow, June 1963, 4 ♀ ♀ in LT, coll. C. O. Berg.

BIOLOGY. *Seasonal distribution.* Adults collected mostly in June, a few in July and August.

Breeding sites. One record, from a Michigan bog (Wirth & Hubert, 1962).

Feeding habits. Bennett (1960) found this species (cited as sp. near *piliferus*) present in tremendous numbers in lakeshore habitats at ground level where it fed in greatest numbers on domestic duck. It also fed in limited numbers on the following birds exposed in cages: grackle, ruffed grouse, white-throated sparrow, blue jay, raven, purple finch, great blue heron and Canada Jay. Fallis and Wood (1957) have shown that *downesi* (as sp. near *piliferus*) is the intermediate host of the protozoan *Haemoproteus nettionis*, a parasite of ducks.

Culicoides flukeyi Jones

Figures 38, 77, 114, 151, 196, 225, 280

Culicoides flukeyi Jones, 1956: 30-32, figures 6-10 (♂, ♀).

FEMALE. Eyes contiguous or very narrowly separated, superior transverse suture present. Proboscis very short, P/H ratio 0.42(0.40-0.43, n=3). Mandible with 6.6(6-7) well developed teeth. Labial palps slightly swollen. Flagellomere length ratios 13/10/10/10/11/10/11/11/-/14/14/14/19/24 (n=3); AR=1.02(1.02-1.03, n=3); sensillar pattern 3, 11-15. Third segment of maxillary palp short, greatly swollen, globose, L/W ratio 1.53; sensory pit deep, with large opening.

Wing length 0.99(0.81-1.10, n=3)mm., with distinct pale spots as indicated in figure 38, resembling the wing pattern of the *piliferus* group, especially with a light spot over the midportion of vein M₂; macrotrichia moderately abundant over most of wing. Legs with distinct pale bands near apex of femur and base of tibia, "knees" dark; five hind tibial spines with the second usually longest.

Two nearly equal subelliptical, lightly pigmented spermathecae with a maximum width of 32-35(n=2) and 33-35(n=2) microns respectively; neck short tapering.

COMMENT. This species closely resembles *denticulatus* differing mainly in having a more pronounced wing pattern, in the shape of the maxillary palp and, less distinctly, in the shape of the sperma-

thecae. It also lacks the fleshy tufted prolongation of the labrum present in *denticulatus*.

MALE TERMINALIA. Ninth tergum with stout apicolateral processes each with a small "nipple" at the tip, these would touch if the processes were directed medially; median notch broad and deep; ninth sternum with a broad, shallow concave posterior emargination, membrane not spiculate. Basistyle with ventral root indicated by a slight projection; dorsal root long, parallel sided.

Paramere gradually tapering to a fine bare point, curving ventrally and posteriorly in a semicircle; paramere swollen at midlength, narrowed posteriorly and joined broadly to anteriorly directed accessory process. Aedeagus with short, broad median posterior process with a rounded nipple-like apex; lateral arms moderately long, arcuate, with a short flange at base.

PUPA. The pupa belongs in the *guttipennis* group and we could not reliably distinguish it from the pupa of *arboricola*. The L/W ratio of the respiratory horns of the two species overlap, for *flukeyi* it is 5.3(4.5-6.5). The number of spiracular openings on the respiratory horn also overlap, *flukeyi* has 9.4(8-11) apical and 3.3(2-4) lateral openings.

FOURTH INSTAR LARVA. Only one cast larval skin and one larva of reared *flukeyi* were available for examination. Frontoclypeus 164 microns long, comb distinctive with 4 teeth on each side; total comb width 11 microns, with sides and top of comb straight rather than rounded as in most species. Setae on last abdominal segment unusually long and stout, longer than maximum width of last segment.

COMMENT. The appearance of the comb and the characteristic long setae on the last abdominal segment indicate that *flukeyi* belongs in the *guttipennis* group.

DISTRIBUTION. N. Y., Wis.

New York State Records (first records from State)

Albany County, E. Berne, Jamnback's woods, larva collected from sugar maple treehole June 13, 1963—5, pupated June ?, ♂ emerged June 21.

Essex County, Newcomb, Hamilton-Essex line beside Rte. 28, larva and pupae all collected July 10, 1959—4, from oak treehole, 2 ♀♀ and 7 ♂♂ reared from pupae and one ♂ from larva between July 10 and 15.

Tompkins County, Freeville, from pitcher plant, June 29, 1935, reared, 1 ♂ and pupal pelt; USNM coll.

BIOLOGY. *Seasonal distribution.* Jones (1956) reared adults between May 30 and June 26 in Wisconsin. New York collection records for adults are late June and July as cited above.

Breeding sites. Limited data indicate that it breeds only in treeholes.

Feeding habits. Unknown. *Flukei* has a short proboscis and few mandibular teeth and probably is not haematophagus.

Culicoides furens (Poey)

Figures 39, 78, 115, 152, 179, 197, 226, 252, 281

Culicoides furens Poey: Painter, 1924: 255-257, figures 2, 5, 9 (pupa, larva).

Culicoides dovei Hall, 1932: 88-89, figure 1 (male); Dove, Hall and Hall, 1932: pl. II, III 1-5, (♂, ♀, pupa, larva, egg).

Culicoides furens (Poey): Fox, 1942: 418-419, figures 8, 12 (pupa); Wirth, 1952b: 95-99, figures 11-18 (pupa, larva); Jones 1961a: 739-741, figures 49-53 (pupa); Wirth & Blanton, 1956: 159-161, figure 1a-h (♂, ♀).

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.85 (0.82-0.89). Mandible with 16.2(15-17) well developed teeth. Flagellomere length ratios 11/7/8/8/9/9/9/9/-/15/16/18/18/24/, AR=1.21(1.13-1.34); sensillar pattern 3, 7-10. Third segment of maxillary palp slightly to moderately swollen, L/W ratio 2.83(2.71-3.00), sensory pit shallow with small opening.

Wing length 1.08(0.96-1.20)mm., with distinct pale spots as shown in figure 39, 3 pale spots in cell R_5 ; macrotrichia moderately abundant present mostly on distal half of wing. Legs with distinct pale bands near apex of femur and base of tibia, "knees" dark; four hind tibial spines with the first longest.

Two subequal, moderately to well pigmented subelliptical spermathecae with a maximum width of 38(36-39) and 35(33-38) microns respectively, neck long parallel sided.

MALE TERMINALIA. Ninth tergum strongly tapering posteriorly with unusually long slender apicolateral processes which would touch if directed medially; median notch deep V-shaped ninth sternum with a narrow deep concave posterior emargination, membrane not spiculate. Basistyle with ventral root "boat-hook" shaped; dorsal root long, slender, parallel sided.

Paramere gradually tapering distally to a fine tip with a row of about six spines, curved dorsally and posteriorly in a loop; paramere

with a distinct large outer swollen lobe just distad of midlength; swollen and lobed basally. Aedeagus with median posterior process moderately long and broad, truncate and ridged apically, lateral arms moderately long, base with or without distinct flange.

PUPA. Respiratory horn pale, darkened apically with 5.7(5-6) apical and 2.7(2-3, $n=3$) lateral spiracular openings, lateral openings each on a prominent projection; median third with transverse convolutions, spines lacking, widest near base, L/W ratio 6.7(6.2-7.6, $n=3$). Operculum with long spines moderately abundant along margins and on disc; *am* seta long and stout, about four-tenths as long as maximum width of operculum. The *d* tubercles 1-3 not in line, setae 1 and 2 closer than 2 and 3, setae 1 and 2 rather short, generally not overlapping, thoracic surface between and adjacent to tubercles with few papillae, nearly smooth.

Abdomen with fine spines confined mostly to anterior margins of segments; *lpm* tubercles bifid with unusually long tapering, fine points. Last segment lacking patch of spines on disc, caudal apico-lateral processes without spines, apical quarter darkened, directed laterally at an angle of 30-60 degrees to the longitudinal axis of the body.

FOURTH INSTAR LARVA. Frontoclypeus 159(150-170, $n=4$) microns long. Comb with 7($n=1$) subequal teeth on each half; total comb width 18($n=1$) microns; head capsule pale yellow, strongly tapering anteriorly.

Thoracic segments with a brownish diffuse mottling over dorsum. Conspicuous on "neck" and prothorax, fainter on mesothorax and often very faint on metathorax.

COMMENT. *Furens*, *haematopotus* and *variipennis* are the only three species in New York State in which the head capsule is strongly tapered anteriorly.

DISTRIBUTION. *Furens* breeds in the salt marshes along the eastern coast northward to Massachusetts and southward to Brazil. On the Pacific coast it is found from Mexico to Ecuador (Wirth & Bianton, 1956, 1959). It reaches its greatest abundance on the islands and mainland bordering the Caribbean Sea. Forattini (1957) has summarized the Caribbean, Central, and South American distribution of *furens*. In North America, north of Mexico, it has been collected in Fla., Ga., La., Md., Mass., Miss., N. J., N. Y., N. C., R. I., S. C., and Tex.

In New York State, *furens* has been collected from many localities in Suffolk and Nassau Counties and probably occurs on Staten Island and in coastal Westchester County.

BIOLOGY. *Seasonal distribution.* In New York State, *furens* adults have been collected between June 28 and August 17, with the largest numbers present during July.

In Panama, Carpenter (1951) reported a gradual buildup in populations of adult *furens* during the rainy season until a peak was reached in November and December. The population then decreased rapidly with the onset of the dry season, presumably due to the limited areas suitable for breeding. The period of annoyance extended from September to January. In Puerto Rico, Fox and García-Moll (1961) reported peak light trap collections from February to June with no consistent correlation with wet or dry periods. They noted, however, that the months of lower tides are the months of greatest abundance of *furens*. This species is apparently progressively less abundant and annoying further north [Hall, 1932, Snow *et al.*, 1959 (South Carolina), Jamnback *et al.*; 1958 (New York), Wall & Doane, 1960 (Massachusetts)]. Unlike Panama and Puerto Rico, where *furens* breeds continuously, there appears to be only one generation per year in the northeastern states. Wall & Doane (1960) point out that *furens* is often collected in considerably larger numbers than *hollensis* (as *canithorax*), in Massachusetts, but that the positions are reversed in biting collections. This suggests that *hollensis* is less attracted to light, or more attracted to man, than *furens*.

Breeding sites. In Florida, the largest numbers of *furens* larvae have been found along drainage ditches, between the high and low tide levels, where the soil is usually covered with a layer of sediment that remains soft and wet (Bidlingmayer, 1957). Carpenter (1952), Woke (1954) and Blanton *et al.* (1955) reported finding larvae in low areas constantly saturated with shallow water or subjected to frequent tidal flooding. The latter two reported finding larvae only rarely in shaded areas, while Goulding *et al.* (1953) and Bidlingmayer (1957) found larvae to be more abundant in shady sections. Wall and Doane (1960) found mixtures of *furens* and *hollensis* to be most abundant along the edges of bays and drainage ditches where *Spartina alterniflora* is the predominant plant cover, but found them to be present throughout the tidal marsh, where the surface remained wet and not compacted.

Feeding habits. There are abundant records indicating that *furens* is a blood-sucking pest of man, especially in the Caribbean area. Buckley (1933, 1934) has shown that it is a vector of the Nematode *Mansonella ozzardi*, a parasite of man, in South America. Their feeding preferences on other animals are little known. The possible

occurrence of the rather similar species *barbosai*, which has been recorded from southern Florida, Panama, Bahamas and Ecuador, should be watched for. Comparative descriptions of the two species are given by Wirth & Blanton (1956). The females can readily be distinguished by differences in the wing pattern. *Furens* has 3 pale spots in cell R_5 and a round and complete pale spot in cell M_{3+4} not touching the margin of the wing. In *barbosai* there are two pale spots in cell R_5 , and the pale spot in cell M_{3+4} forms an incomplete semicircle with the widest portion at the hind margin of the wing.

Culicoides furenoides Williams
Figures 40, 79, 116, 153, 187

Culicoides furenoides Williams, 1955c: 271-274, figures 7-12 (♂, ♀).

FEMALE. Eyes narrowly to moderately separated. Proboscis short, P/H ratio 0.54($n=1$). Mandible with 8($n=1$) moderately well developed teeth. Labial palps slightly swollen. Flagellomere length ratios 13/8/7/7/9/9/9/9/-/10/10/11/11/17 ($n=1$); $AR=0.80$ ($n=1$); sensillar pattern 3, 8-10. Third segment of maxillary palp very short moderately swollen, L/W ratio 2.25($n=1$), sensory pit shallow with large opening.

Wing length 0.96($n=1$)mm., with distinct pale spots as indicated in figure 40, with only two pale spots in cell R_5 ; macrotrichia only moderately abundant, confined mainly to apical half (except anal cell). Legs with distinct pale bands near distal end of femur and base of tibia, "knees" dark; five hind tibial spines, with the second longest.

Two nearly equal pyriform, moderately pigmented spermathecae with a maximum width of 27 and 29($n=1$) microns respectively, neck long parallel sided.

MALE TERMINALIA. Two specimens seen. Closely resembling *furens* except the swollen lobe of the paramere just distad of the mid-length is smaller, the median posterior process of the aedeagus shorter and narrower, and the lateral arms more heavily sclerotized with a distinct, short, basal flange (cf. figures 7 and 8).

PUPA and LARVA. Unknown.

DISTRIBUTION. Mich., N. Y.

New York State Record (first record from State)

Monroe County, Braddock Bay, near marsh, June 12, 1963, 1 ♂. coll. WWW.

BIOLOGY. *Seasonal distribution.* The type specimens were collected from a recovery cage on July 22, 1954. A later collection by Williams in the NYSM collection consisting of a ♂ and a ♀ is dated July 2-9, 1959.

Breeding sites. Williams' specimens were recovered over a sphagnum mat at the edge of a pond.

Feeding habits. Unknown. The proboscis is short and the mandibular dentition reduced.

Culicoides guttipennis (Coquillett)

Figures 41, 80, 117, 154, 198, 227, 270, 272, 282

Ceratopogon guttipennis Coquillett: Pratt, 1907: 23-26, figures 3, 4 (♀, pupa, larva).

Culicoides guttipennis (Coquillett): Fox, 1942: 415, figures 3, 8 (pupa); Foote & Pratt, 1954: 22-23, figures 29, 55, 80, 108 (♂, ♀); Jones & Wirth, 1958: 84-86 (♀).

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.99(0.95-1.07). Mandible with 20.8(19-22, n=6) well developed teeth. Flagellomere length ratios 14/11/13/13/13/13/14/14/-/27/26/30/31/36, AR=1.47(1.36-1.68), sensillar pattern 3, 5, 7, 9, 11/15. Third segment of maxillary palp slightly swollen, L/W ratio 3.10(2.67-3.25), sensory pit deep with large opening.

Wing length 1.40(1.17-1.47)mm., with distinct pale spots as indicated in figure 41, resembling *arboricola* but differs in having vein Cu₁ entirely in a dark area; macrotrichia abundant. Legs with distinct pale bands near apex of femur and base of tibia, "knees" dark; five hind tibial spines with second usually longest (or 1 and 2 subequal and longest).

Two subequal slightly asymmetrical heavily pigmented subelliptical spermathecae with a maximum width of 46(44-48) and 51(50-53) microns respectively; neck short blunt and tapering.

MALE TERMINALIA. Ninth tergum with unusually stout apico-lateral processes which would not touch if directly medially; median notch very shallow, often visible only as a slight depression; ninth

sternum with a broad deep concave posterior emargination, membrane spiculate. Basistyle with ventral and dorsal roots strongly tapered, dorsal root longer.

Paramere little tapered near tip, coming to a rather blunt, bare point, angled outwardly near distal end, then curving in a semicircle so that the tip is directed inwardly; paramere gradually more swollen posteriorly, base swollen and rounded. Aedeagus with a long median posterior process nearly parallel sided but slightly swollen at mid-length, superficially terminating in a truncate ridged apex, on close examination a lightly sclerotized rounded "cap" distad to the truncation can be seen; lateral arms short, slightly curved out near base.

COMMENT. In addition to the distinctive characters noted above this is the only species in which the dististyle is strongly bent at midlength and in which the inner ventral margin of the basistyle is strongly curved near the base.

PUPA. Respiratory horn uniformly light brown, darker than rest of pupa, with 13.2(11-15) apical and 2.2(2-3) lateral spiracular openings; short and stout, widest toward the tip at about the level of the basalmost apical spiracular opening, L/W ratio 4.5(3.6-5.3), no transverse wrinkling, surface covered with small spines. Operculum almost entirely covered with short stout spines; *am* setae long and slender, more than half as long as maximum width of operculum. The *d* tubercles 1-3 in line, 1 and 2 closer than 2 and 3, setae 1 and 2 very short; thoracic surface between and adjacent to tubercles covered with fine papillae.

Abdomen covered with modified flattened, confluent spines giving it a scale-like appearance, often with blunt points, or points indicated only by an angle. The *lpm* tubercles each bifid, setae unusually long; last segment with dorsum covered with fine spines; caudal apicolateral processes with numerous fine spines, tip not darkened apically, directed posteriorly at an angle of less than 30 degrees from longitudinal axis of body.

FOURTH INSTAR LARVA. Head pale yellow, elongate, length 238(229-248) microns; comb with 6(5-7, $n=8$) teeth on each side; total comb width 29(26-33) microns; sides and top of comb straight rather than rounded as in most other species; head capsule pale yellow.

Prothorax with pigmented areas covering most of the anterior half of the dorsum, extending somewhat further back on each side; meso- and metathorax pigmented on both sides but not on dorsum as indicated in figure 282. The thoracic markings are often rather faint. Setae on last segment unusually long and stout, longer than maximum width of last segment.

DISTRIBUTION. *Guttipennis* is a common treehole breeding species east of the Mississippi and has been collected as far north as New York and Vermont and south to Florida, but has been collected less frequently west of the Mississippi River, and seems to be less abundant in the south than in the north. The extensive collecting of Beck (1958) in Florida produced no specimens although Foote & Pratt (1954) record it from that State. Similarly, Wirth & Bottimer (1956) and Jones & Wirth (1958) did not collect it in Texas although it has been recorded from there. It is the most common treehole breeder in New York State.

North American distribution: Ala., Ariz., Conn., Fla., Ga., Ill., La., Md., Mass., Mich., Miss., N. Y., Ohio, Okla., Tenn., Tex., Va., Vt., and Wis. Although it has not been recorded from southeastern Canada, it almost certainly occurs there, since it has been collected in New York near the St. Lawrence River, just across the border from Canada.

New York State Records

In New York State it has been collected in Albany, Cattaraugus, Essex, Hamilton, St. Lawrence, Suffolk, Tompkins, and Washington Counties, and probably occurs throughout the State.

BIOLOGY. *Seasonal distribution.* Adults of *guttipennis* have been collected from early spring (April) until early fall (October) in the southeastern U. S. (Pickard & Snow, 1955; Snow 1955; Snow *et al.*, 1957; Williams, 1955a). In Virginia, Murray (1957) collected large numbers in light traps from late June to mid-July with smaller numbers present until the end of the collecting period in early September. Pratt (1907) kept larvae alive over the winter in the laboratory and found they emerged in the spring. Foote & Pratt (1954) collected active larvae in January in Georgia. In New York State, adults have been reared between April 16 and August 9, and are probably present from spring to fall.

Breeding sites. All records indicate that this species along with *arboricola*, *flukeyi*, and *villosipennis*, breeds exclusively in moist or wet treehole cavities.

Feeding habits. Although *guttipennis* has several times been reported feeding on man, and on horses and cattle (Pratt, 1907; Malloch, 1915; Snow *et al.*, 1957; Murray, 1957), its biting preferences are not well known. The fact that we have never been bitten by this species while spending long periods in areas where the adults are

abundant, its preference for the forest canopy rather than ground level (Snow, 1955), and the presence of sensilla on all flagellomeres suggest that it may be primarily ornithophilic.

Culicoides haematopotus Malloch

Figures 42, 81, 118, 155, 199, 228, 253, 283

Culicoides haematopotus Malloch: Thomsen, 1937: 70, figures 92, 125 (pupa); Foote & Pratt, 1954: 23-24, figures 26, 53, 70, 103 (♂, ♀); Jones, 1961a: 739, figures 45-48 (pupa).

FEMALE. Eyes narrowly to moderately separated. Proboscis of intermediate length 0.70(0.67-0.73). Mandible with 9.8(8-11) well developed teeth. Flagellomere length ratios 12/6/6/6/7/7/7/8/-/18/19/20/22/27, AR=1.73(1.66-1.78), sensillar pattern 3, 5-15. Third segment of maxillary palp greatly swollen, L/W ratio 2.18 (2.00-2.38), sensory pit moderately shallow with large opening.

Wing length 1.08(0.96-1.16)mm., with numerous light spots as shown in figure 42, pale spot over r-m cross-vein not extending basad of vein; macrotrichia moderately abundant. Legs with distinct pale bands near apex of femur and base of tibia, "knees" dark; four hind tibial spines with the first longest.

Two subequal, subelliptical, often asymmetrical, lightly pigmented spermathecae with a maximum width of 38(38-39) and 34(33-36) microns respectively; necks long and parallel sided; sclerotized ring of genital duct unusually heavily sclerotized and tapering.

COMMENT. See *baueri*.

MALE TERMINALIA. Ninth tergum strongly tapered posteriorly with slender apicolateral processes which would not touch if directed medially; median notch very shallow, often inapparent; ninth sternum with a narrow, shallow concave posterior emargination, membrane not spiculate. Basistyle with slender "boat-hook" shaped ventral root; dorsal root moderately long parallel sided.

Paramere terminating apically in a rather broad tip with a row of about six well developed spines, spine-bearing portion curved outwardly and posteriorly; paramere with a swollen lobe on outer surface just distad of midlength; base only slightly swollen, without flange. Aedeagus with long, slender, parallel sided median posterior process, truncate and ridged at tip; with two small lateral posterior

processes on lateral arms, one on either side of median posterior process; lateral arms short, basal flanges weakly indicated or absent.

COMMENT. This species and *baueri* are the only New York State species with lateral posterior processes on the aedeagus. *Baueri* males can be distinguished from *haematopotus* by the lack of a swollen lobe near midlength on the paramere, by the longer lateral arms of the aedeagus (see Foote & Pratt, 1954), and by differences in the wing pattern (see *haematopotus* females).

PUPA. Respiratory horn light brown concolorous with rest of pelt on basal half, third quarter pale, last quarter dark brown, with 4.6 (4-6) apical and 3 lateral spiracular openings, the lateral ones on pronounced protuberances, pale portions of horn just distad of midlength with pronounced transverse convolutions, no spines except for a few on the distal quarter; widest near base, L/W ratio 6.2 (5.6-7.9). Operculum with moderately long spines along lateral margins and on disc, bare posteriorly; the lateral margin of the operculum of *haematopotus* has an unusual and distinctive outward bulge at about the midlength; *am* setae less than three-tenths as long as maximum width of operculum. The *d* tubercles 1-3 not in line or equidistant, with tubercles 1 and 2 almost touching, setae 1 and 2 short, but overlapping or nearly overlapping; thoracic surface between and adjacent to tubercles with fine papillae moderately abundant. Abdomen with fine spines confined mostly to anterior margins of segments, sparse elsewhere. The *lpm* tubercles rounded or with blunt points, with a subapical seta. Last segment with a patch of spines on disc; caudal apicolateral processes with fine spines, apical quarter darkened, directed posteriorly at an angle of 20 to 30 degrees to the longitudinal axis of the body.

COMMENT. The appearance of the respiratory horn of *haematopotus*, *baueri*, *furens*, and *stellifer* suggests their close relationship. All have a pronounced transverse wrinkling at about midlength, and lateral spiracular openings located on pronounced dorsally directed protuberances.

FOURTH INSTAR LARVA. Frontoclypeus 122(119-126)microns long. Comb with 7($n=2$) unequal teeth on each half; total comb width 16.9(15-18) microns; head capsule pale yellow, strongly tapered anteriorly.

Thoracic segments with a reddish-purple mottled pigmentation extensive on the dorsum of the pro- and mesothorax and faintly suggested on the metathorax as indicated in figure 283.

(Note. The swollen appearance of the thorax and the eye spots far back on the head capsule shown in this figure are typical for early

prepupal larvae of the genus rather than a useful specific character for *haematopotus*.)

COMMENT. The pattern of pigmentation on the thorax of *haematopotus* larvae is unique among the species we have studied.

DISTRIBUTION. *Haematopotus* is a widespread species that has been recorded from most of the states in the southern two-thirds of the United States and, east of the Mississippi River, and as far north as Maine and Michigan. It has been recorded from Ala., Calif., Colo., D. C., Fla., Ga., Ill., Kan., La., Me., Md., Mexico, Mich., Neb., Nev., N. Y., N. M., Ohio, Ont., Pa., Tenn., Tex., Utah, Va., and Wis.

Light trap collections data suggests that the species becomes progressively less abundant from south to north (Wirth & Bottimer, 1956, Tex.; Khalaf, 1952, Okla.; Williams, 1955a, Ga., 1955b, Mich.; James, 1943, Colo.; Murray, 1957 Va.; Snow *et al.*, 1957, Tenn., and Ala.; Coher *et al.*, 1955, Me.; and Downes, 1958, southeastern Canada).

In New York State, *haematopotus* has been collected from Cattaraugus, Chautauqua, Genesee, Hamilton, Lewis, Livingston, Monroe, St. Lawrence, Suffolk, and Tompkins Counties, and probably occurs throughout most of the State. Although widespread it was not collected in large numbers.

BIOLOGY. *Seasonal distribution.* *Haematopotus* adults have been collected in approximately equal numbers from spring until fall in other areas (James, 1943; Wirth & Bottimer, 1956; Snow *et al.*, 1957). In New York State, adults were present mostly in late May and June. Bennett (1960) collected this species in relatively small numbers mostly in June to July at Algonquin Park, Ontario.

Breeding sites. Larvae and pupae have been collected mostly along the margins of streams, ponds, or pools with a substrate of moist or wet sand, mud, or decaying leaf mold (Wirth, 1951b; Williams, 1955a; Wirth & Bottimer, 1956; Murray, 1957; Snow *et al.*, 1957). Jones (1959) has collected it breeding in small numbers in septic tank effluents. Of our reared specimens, 29 ♂♂ and 41 ♀♀ were reared from immatures taken from 15 sites along stream margins; 3 ♂♂ and 4 ♀♀ from a muddy sand bar in a stream; 3 ♂♂ and 6 ♀♀ from a river-side pool; 1 ♂ from a pond margin; and 5 ♂♂ and 2 ♀♀ from a swamp.

Feeding habits. Although we have not collected this species biting man in New York State, a number of workers elsewhere have, but apparently never in numbers (Malloch, 1915; Edmunds & Keener,

1954; Snow, 1955; Downes, 1958). Fallis & Bennett (1960, 1961a) found *haematopodus* feeding on crows and spruce grouse in small numbers. Snow (1955) noted that it was more common in the forest canopy than at ground level. The large number of sensilla on the antenna provide confirmation of observation that it is primarily ornithophilic.

Culicoides hollensis (Melander & Brues)

Figures 43, 82, 119, 156, 200, 229, 254, 269, 274, 284

Culicoides canithorax Hoffman: Foote & Pratt, 1954: 17-18, figures 13, 35, 66, 79, 97, 99 (♂, ♀); Jamnback *et al.*, 1958: 69-70, figures 3, 5, 7, 9, 11 (pupa, larva).

Culicoides hollensis (Melander & Brues): Wirth, 1963: 68.

FEMALE. Eyes widely separated. Proboscis long, P/H ratio 0.95 (0.88-1.00). Mandible with 12.5(11-13) well developed teeth. Flagellomere length ratios 13/9/9/9/9/9/9/9/-/14/15/17/18/24, AR=1.11(1.00-1.19); sensillar pattern 3, (11), 13-15. Third segment of maxillary palp slightly swollen, L/W ratio 3.14(2.86-3.50), with small, shallow sensory pit.

Wing length 1.13(1.07-1.19)mm., with light spots as shown in figure 43, much less distinct than indicated by Foote & Pratt (1954); macrotrichia sparse to moderately abundant but unusually short. Legs without distinct pale bands; hind tibial spines 4 with first or second longest.

One well pigmented elliptical spermatheca 76(68-87) microns maximum width, neck short parallel sided.

MALE TERMINALIA. Closely resembling *crepuscularis* (also see *wisconsinensis*.) The most reliable differences are: the degree of swelling of the dististyle, in *hollensis* the basal half or more is swollen, in *crepuscularis* less than half is swollen (cf. figures 5 and 11); the dorsal root of *hollensis* is more robust and tapers more gradually to a blunter point than that of *crepuscularis*; the distal end of the median posterior process of the aedeagus is usually truncate in *hollensis* and rounded in *crepuscularis*.

The wings of *crepuscularis* males are distinctly marked in a pattern resembling that of the female, while those of *hollensis* are very faintly marked or the markings are inapparent.

PUPA. Respiratory horn light brown, concolorous with rest of pupa except darkened apically with 13.4(12-16) apical and 5(4-6) lateral

spiracular openings, the lateral ones on pronounced protuberances; no transverse convolutions or spines; wildest near base, L/W ratio 5.3 (4.7-5.9). Operculum with moderately long stout spines along both lateral margins and on disc, bare posteriorly; *am* setae long and slender, almost four-tenths as long as maximum width of operculum, *d* tubercles 1-3 not quite in line, 1 and 2 closer than 2 and 3, often very close together, setae 1 and 2 very long subequal, overlapping; thoracic surface between and adjacent to tubercles nearly smooth.

Abdomen with fine spines confined mostly to anterior margins of segments, sparse elsewhere. The *lpm* tubercles rounded or blunt pointed with an apical or nearly apical seta. Last segment without a patch of spines on disc; caudal apicolateral processes without small scales, tips not darkened, directed laterally at about a right angle to the longitudinal axis of the body.

COMMENT. In addition to the distinguishing characters given above, *hollensis* is the only species outside of the *obsoletus* group and *venustus* whose pupae have two long and subequal *ad* setae.

FOURTH INSTAR LARVA. Frontoclypeus 209(204-228) microns long. Comb with 11.8(11-12) unequal teeth on each half; total comb width 33.3(32-35) microns; head capsule pale yellow.

Dorsally and laterally prothorax lightly and rather uniformly pigmented a reddish-brown; mesothorax similar to prothorax but has, in addition, a distinct dorsolateral circular spot at midlength on each side. Metathorax with lighter general pigmentation less distinct or absent posteriorly; dorsolateral spots more elongate than those of mesothorax.

COMMENT. *Hollensis* larvae resemble those of *crepuscularis* and *wisconsinensis* but can be distinguished by the longer head capsule, larger comb with more teeth, and less extensive thoracic pigmentation.

DISTRIBUTION. *Hollensis* breeds only in salt marshes along the east and Gulf coasts. It has been recorded from Del., Fla., Ga., La., Me., Md., Mass., Mexico, Miss., N. J., N. Y., R. I., and S. C.

In New York State it has been collected from numerous localities in Nassau and Suffolk Counties.

BIOLOGY. *Seasonal distribution.* Adults have been collected while biting man from May 29 through August 29 (collections were not made after the latter date) on Long Island. Reared adults have emerged as early as April 28 in this area. Adults were most abundant in the early and late summer with relatively few present in the interim period from late June through early August (Jamnback *et al.*, 1958). These findings agree with earlier observations by Dove, Hall, and Hull (1932). Beck (1952, 1958) recorded peak abundance in

the spring (March-May) in Florida but noted they were present year round. Lewis (1959) reported a peak abundance period in late July in Connecticut.

Breeding sites. On Long Island, larvae and pupae were collected from portions of salt marshes with *Spartina alterniflora*, *Sp. patens*, *Distichlis spicata*, *Scirpus* spp., or *Salicornia* spp. as the dominant plant cover. Larvae were particularly abundant in wet marsh that was covered by almost every high tide, where *Sp. alterniflora* grew to a height of two feet or more and where the sod had a thin covering of soft mud which served as the larval substrate (Jamnback *et al.*, 1958). On Cape Cod in Massachusetts, Wall & Doane (1960) found numerous larvae along the margins of the bays and drainage ditches where long *Sp. alterniflora* was the dominant plant cover.

Feeding habits. This species, together with *melleus*, is the most important *Culicoides* attacking man in coastal New York State. Coher *et al.* (1955), Shaw (1959), and Wall & Doane (1960) pointed out its importance in various parts of New England. In the northeastern coastal region of the United States it is more important than *furens* as a pest of man although farther south *furens* is the chief coastal pest species. The hosts of *hollensis* other than man are not known.

Culicoides jamnbacki Wirth & Hubert
Figures 44, 83, 120, 157, 201, 230, 255, 285

Culicoides jamnbacki Wirth & Hubert, 1962: 192, figures 8a-g, 16 (♂, ♀).

FEMALE. Eyes narrowly to moderately separated. Proboscis short, P/H ratio 0.63(0.62-0.67). Mandible with 12.2(10-14, n=6) well developed teeth. Flagellomere length ratios 12/8/8/8/9/8/8/8/-/14/15/15/16/25, AR=1.16(0.97-1.24); sensillar pattern 3, (5), 7, 9, (11), 13-15. Third segment of maxillary palp moderately swollen, L/W ratio 2.50 (2.25-2.79), sensory pit shallow with small to moderate opening.

Wing length 1.16(1.10-1.25)mm., with faint pale spots, one just beyond second radial cell and one over r-m cross-vein often very faint or absent, elsewhere macrotrichia sparse to moderate. Legs with only faint pale banding; 4 hind tibial spines with the second longest.

Two very unequal subelliptical lightly pigmented spermathecae with a maximum width of 56(54-60) and 40(38-44) microns respectively; neck absent or, if present, very short parallel sided.

COMMENT. Uncleared specimens of *jamnbacki* superficially resemble *biguttatus*. A useful sorting character is that antennomeres 4-10 of *jamnbacki* are only slightly longer than broad (about 1.3 times), while those of *biguttatus* are about two times as long as broad. MALE. Closely resembles *piliferus*.

PUPA. Respiratory horn uniformly brown, darker than rest of pelt with 5 apical and 3 lateral spiracular openings; median two-thirds with a few well developed spines, lacking transverse convolutions, horn widest near base, L/W ratio 5.8(4.7-6.9). Operculum with distinct spines along lateral margins, disc with papilliform spines; *am* setae long and slender, almost 0.4 as long as maximum width of operculum. The *d* tubercles 1-3 in line, 1 and 2 closer than 2 and 3, setae 1 and 2 moderately long, overlapping or almost overlapping; thoracic surface between and adjacent to tubercles nearly smooth.

Abdomen with fine spines confined mostly to anterior margins of segments, but with others moderately abundant scattered over segments. The *lpm* tubercles usually bifid, often with one of the points weaker than the other, last segment with a patch of spines on disc; caudal apicolateral processes with small spines present and apical quarter darkened, directed posteriorly at an angle of 30 degrees or less to the longitudinal axis of the body.

FOURTH INSTAR LARVA. Frontoclypeus 212(201-228, n=6) microns long. Comb with 7.5(7-8, n=6) unequal teeth on each half; total comb width 31(29-33) microns; head capsule yellow, frontoclypeus slightly darkened.

Thorax with distinct dark markings. Dorsum of prothorax with a transverse bar near anterior margin; mesothorax with transverse bar and oval lateral markings; metathorax with longer and wider lateral markings, as shown in figure 285.

DISTRIBUTION. *Jamnbacki* was described in 1962 by Wirth & Hubert who recorded it from Mich., Ont., and N. Y.

New York State Records

Albany County, E. Berne, June 20, 1963, LT in woods, 1 ♀, coll. HAJ.

Cattaraugus County, Allegany State Park, May 28-June 3, 1963, 3 ♀ ♀ in LT, coll. WWW.

Essex County (Wirth & Hubert, 1962).

Lewis County, Watson, Pine grove, June 22, 1963, 2 ♀ ♀ in LT, coll. WWW.

Hamilton County (Wirth & Hubert, 1962).

Suffolk County, North Sea, Big Fresh Pond Outlet, muddy stream margin, June 5, 1963, reared 1 ♀, coll. HAJ.

Tompkins County, Ellis Hollow, June 1963, 9 ♀ ♀ in LT, coll. C. O. Berg.

BIOLOGY. *Seasonal distribution.* This is an early spring species, with adults present in May and June. In Michigan, small numbers of adults were collected in June and July and in Ontario in late June (Wirth & Hubert, 1962).

Breeding sites. Larvae and pupae of *jamnbacki* have been collected primarily from woodland sites including seeps, stream margins, temporary pools, swamps and marshes. The substrate was soft mud, either bare or covered by a sparse growth of sphagnum, or grass, or decaying leaves. In general this species is found in very wet sites, often beneath the water.

Feeding habits. Unknown. Although the mouthparts are short, the mandibular teeth and tormae are well developed.

Culicoides loisae, new species

Figures 45, 84, 121, 158, 180, 202, 231, 256

FEMALE. Eyes very narrowly separated or contiguous, with superior transverse suture present. Proboscis short, P/H ratio 0.50(0.42-0.63). Tip of labrum with unusual and distinct fleshy tufted distal prolongation. Labial palps slightly swollen. Mandibular teeth absent. Flagellomere length ratios 12/8/8/8/8/9/9/10/-/13/14/16/17/21, AR=1.12(1.00-1.33); sensillar pattern segments 3, 11-15. Third segment of maxillary palp short, moderately swollen, L/W ratio 2.08 (2.00-2.26) sensory pit shallow with moderately large opening.

Wing length 1.00(0.93-1.05)mm., with faint pale spots over r-m cross-vein and just distad of second radial cell; macrotrichia moderately abundant, arranged in roughly linear pattern. Legs without distinct pale bands; four hind tibial spines with the first or second longest.

Two subequal moderately sclerotized elliptical spermathecae with

a maximum width of 37(36-39) and 39(38-41) microns respectively, long parallel sided or slightly tapered neck.

COMMENT. The female of this species resembles *denticulatus* but is smaller, has a different antennal ratio, and has legs with 4 rather than 5 hind tibial spines. In common with *melleus*, *spinosus*, and *stilobezzioides*, the sclerotized ring is absent (see *spinosus*).

MALE TERMINALIA. Very closely resembling *spinosus* except ninth tergum less strongly tapered, apicolateral processes slightly stouter and shorter, would not touch if directed medially, median notch indicated only by a slight depression instead of a deep emargination; median posterior process of aedeagus slightly shorter and stouter, lateral arms without flange at base.

COMMENT. The most conspicuous differences are in the less deeply notched posterior margin of the ninth tergum, and smaller apicolateral processes.

PUPA. Respiratory horn brown, slightly darker distally, with 6.2 (6-7) apical and 2.8(2-3) lateral spiracular openings; basal two-thirds with scale-like spines moderately abundant; widest near base, L/W ratio 6.9(4.6-8.3). Operculum with moderately long stout spines extending far back along lateral margins, disc bare; *am* setae short and stout, less than one-third as long as maximum width of operculum. The *d* tubercles 1-3 in line, nearly equidistant, spines 1 and 2 subequal, moderately long, do not overlap; thoracic surface between and adjacent to tubercles strongly papillate.

Abdomen with spines confined mostly to anterior margins of segments, sparse elsewhere. The *lpm* tubercles elongate, usually with single apical point and subapical seta. Last segment without a patch of spines on disc; caudal apicolateral processes with spines, apical half darkened, directed at an angle of about 45 degrees to longitudinal axis of body.

COMMENT. *Loisae* pupae differ from *denticulatus* most conspicuously in having the abdominal segments with setae confined to a band near the apical margin instead of scattered over the segments. They differ from those of *utowana* in lacking papillae on the disc of the operculum, lacking transverse wrinkling near the base of the respiratory horn, and in the angle of the caudal apicolateral processes.

LARVA. Unknown.

TYPE SPECIMENS, HOLOTYPE: reared female with pupal pelt. McLean Reserve, Tompkins County, N. Y. June 18, 1963. ALLOTYPE: reared ♂ with pupal pelt, Freeville, Tompkins County, June 19, 1963. PARATYPES: 25 ♂♂ and 24 ♀♀ collected by W. W. Wirth; 1 ♂ and 1 ♀ collected by J. E. Scanlon. Holotype, allotype

and 41 paratypes deposited in the U. S. National Museum collection; 10 paratypes deposited in the N. Y. State Museum.

DISTRIBUTION. (All first records from states listed) Md., (Patuxent Wildlife Refuge, May 22, 1959, 1 ♂ and 1 ♀ in LT, coll. J. E. Scanlon); N. Y. (see below); Va. (Falls Church, stream margin, July 4, 1950, reared 2 ♀ ♀ with pupal pelts; same location, June 30, 1951, reared 2 ♂ ♂ with pupal pelts; same location, July 22, 1951, reared 2 ♂ ♂ and 3 ♀ ♀ with pupal pelts; Holmes Run, September 5, 1961, 1 ♂ in LT; same location September 10, 1961, 1 ♂ and 1 ♀ in LT, coll. WWW.); W. Va., (Cranberry River, July 15, 1955, 1 ♂ at light, coll. WWW.).

I take pleasure in dedicating this species to my wife, Lois Jamnback.

New York State Records (first records from State)

Cattaraugus County, Allegany State Park, stream margin, May 28-June 3, 1963, reared 11 ♂ ♂ and 13 ♀ ♀ with pupal pelts; same data except in sphagnum bog, 1 ♀, coll. WWW.

Hamilton County, Blue Mountain L., Mud Pond Outlet, sand bar, June 10, 1960, reared 2 ♂ ♂ and 1 ♀ with pupal pelts; Fishing Brook, stream margin, June 10, 1960, reared 1 ♀ with pupal pelt, coll. WWW.

Tompkins County, Freeville, Mud Creek, clay bank, June 19, 1963, reared 6 ♂ ♂ and 3 ♀ ♀ with pupal pelts, coll. WWW.

BIOLOGY. *Seasonal distribution.* Although most of the adults were collected in May and June, a few were collected as late as September.

Breeding sites. Stream margins and sand bars with substrates ranging from sandy mud to clay.

Feeding habits. Non-haematophagus.

Culicoides melleus (Coquillett)

Figures 46, 85, 122, 159, 203, 232, 257, 286

Culicoides melleus (Coquillett): Foote & Pratt, 1954: 27, figures 2, 33, 88, 113 (♂, ♀); Wirth, 1952: 94-95, figures 1-10 (pupa, larva); Jamnback *et al.*, 1958: 67, 69, figures 2, 4, 6, 8, 10 (pupa, larva); Jones, 1961a: 735, figures 19-25 (pupa).

FEMALE. Eyes narrowly separated. Proboscis of intermediate length, P/H ratio 0.67(0.60-0.73). Mandible with 11.4(10-13) well developed teeth. Flagellomere length ratios 12/8/8/8/8/8/8/-/12/12/14/15/21, AR=1.10(1.03-1.23); sensillar pattern, 3, 10-14 (absent on 12 on one specimen and 10 on another). Third segment of maxillary palp greatly swollen but unusually short, L/W ratio 2.24 (2.11-2.43), lacking usual sensory pit but with many sensory areas scattered over segment.

Wing length 1.05(0.98-1.17)mm., wing uniformly pale; macrotrichia sparse, mostly on apical half. Legs without pale banding; 4 hind tibial spines with the second usually longest.

Two subequal, heavily pigmented, round spermathecae with a maximum width of 51(50-53) and 48(45-53) microns respectively; neck short, slightly tapered.

COMMENT. *Melleus* can readily be recognized by a number of unique features. It is the only pale yellow species in New York State, the only species without a well developed single sensory pit on the third maxillary palp. It has a unique sensillar pattern, and with *loisac*, *spinosus*, and *stilobezzioides*, is the only species with two spermathecae that lacks a sclerotized ring on the common duct.

MALE TERMINALIA. Ninth tergum with long stout apicolateral processes which would touch if directed medially; median notch a broad shallow V-shaped depression; ninth sternum with narrow, shallow concave posterior emargination, membrane spiculate. Basistyle with ventral root long and slender; dorsal root shorter, stouter, parallel sided.

Paramere, short and stout, tapering rapidly to a bare, blunt distal point, tips directed outwardly, paramere slightly narrowed at mid-length, base narrowly joined to swollen, complex, posteriorly directed accessory process. Aedeagus with short, broad median posterior process terminating in an unusual sclerotized caplike structure (figure 13), lateral arms long, slightly curved outwardly at base.

PUPA. Respiratory horn slightly darker than rest of pupal skin with pale area on second quarter, with 18(15-20) apical and 4.8(4-7) lateral spiracular openings, transverse convolutions present in pale area on second quarter, no spines, widest near base at protuberance where all lateral spiracular openings are located, L/W ratio 4.6 (3.7-5.5). Operculum with moderately long spines along margins and very few elsewhere; *am* setae very slender, about one-third as long as maximum width of operculum. The *d* tubercles 1-3 not in line, 1 and 2 side by side, contiguous, setae 1 and 2 fine, long, subequal; thoracic surface between and adjacent to tubercles with coarse low reticulate surface.

Abdomen with fine spines confined mostly to anterior margins of segments. The *lpm* tubercles rounded apically; last segment lacking a patch of spines on disc, caudal apicolateral processes without spines, apical third or less darkened, directed at about right angles to longitudinal axis of body.

COMMENT. *Melleus* pupae have a unique respiratory horn with all of the lateral spiracular openings on a single protuberance. Most species have the lateral spiracular openings occurring singly and widely separated. In addition to being side by side and contiguous, *d* tubercles 1 and 2 are very lightly pigmented and appear as two pale spots on the thorax when examined under low magnification.

FOURTH INSTAR LARVA. Frontoclypeus length 161 (143-170) microns, Comb with 6.8 (6-7) unequal teeth on each half; total comb width 25 (23-26) microns, head capsule very pale yellow, thinly sclerotized, ventrally with 3 longitudinal lines of heavier sclerotization, one along the midline and one on each side.

Thorax with faint lateral markings on meso- and metathorax as indicated in figure, often not apparent.

COMMENT. *Melleus* larvae are unique in possessing 3 longitudinal dark brown bands on the venter of the head capsule. Since the rest of the head capsule is unusually lightly sclerotized, these lines of heavier sclerotization probably serve to make it more rigid.

DISTRIBUTION. *C. melleus* has been recorded from Mississippi and Florida northwards along the eastern coast of the United States to Maine. It has been recorded from Conn., Del., Fla., Ga., La., Me., Mass., N. Y., R. I., and S. C., and probably occurs in every state along the east coast. It has not been recorded from Canada or Mexico.

In New York, it is widely distributed in Suffolk County on Long Island (Jamnback & Wall, 1958) and probably occurs in the other counties bordering the ocean or Long Island Sound.

BIOLOGY. *Seasonal distribution.* In New York, *C. melleus* reaches peak numbers in mid-summer and is the most important nuisance species along the coast. Beck (1958) states that it is most abundant from March to May in Florida. On Long Island there is apparently only one generation per year. The larvae overwinter and the first pupae are found in early May. Pupation reaches a peak during the second half of June with few pupae present by late July. The first small larvae of the season are found in July, presumably hatching from eggs laid by recently emerged females. Small larvae are found during the rest of the summer, suggesting an extended period of

oviposition. Details of the biology are given in papers by Jamnback & Wall (1958) and Jamnback *et al.* (1958).

Breeding sites. This species breeds only along the coastline in intertidal sand, usually in protected bays or inlets where they are not exposed to prolonged and heavy wave action. This unusual breeding habitat was apparently first recorded by Goulding *et al.* (1953) in Florida.

Feeding habits. This species is a serious pest of man along the coast (Foote & Pratt, 1954; Beck, 1952; Coher *et al.*, 1955; Hoffman, 1925 and others). It is apparently relatively more important in the northern coastal area (Jamnback *et al.*, 1958; Wall & Doane, 1960) than in the south (Goulding *et al.*, 1953 and others). Other host species have not been recorded.

Culicoides niger Root & Hoffman
Figures 48, 86, 123, 160, 204, 223

Culicoides niger Root & Hoffman: Fox, 1942: 417, figures 20, 22 (pupa); Foote & Pratt, 1954: 22, 40, 90, 122 (♂, ♀).

FEMALE. One specimen seen. Eyes narrowly to moderately separated. Proboscis long, P/H ratio 0.84. Mandible with 16 well developed teeth. Flagellomere length ratios 15/9/9/10/10/10/11/-/16/16/18/18/25, AR=1.13; sensilla on all flagellomeres. Third segment of maxillary palp greatly swollen, L/W ratio 2.14, sensory pit shallow with very large opening.

Wing length 1.28 mm., with pale spot over r-m cross-vein and a unique pale band extending transversely across wing, beginning just beyond second radial cell; macrotrichia abundant. Legs with faint pale bands; with 4 hind tibial spines, the second one longest.

Two heavily pigmented spermatheca, one elliptical and the other very long elliptical about twice as long as wide; maximum width of both 42 microns; necks not discernible in specimen examined.

COMMENT. A dark brown species which can easily be distinguished from *alexanderi niger*, and *pseudopiliferus* by the differences in the sensillar pattern. The very long second spermatheca is probably abnormal, since Root & Hoffman note that the two spermathecae are oval and about 68 by 42 microns in the type description.

MALE TERMINALIA. One specimen seen. Ninth tergum with slender apicolateral processes which would not touch if directed

medially; median notch narrow V-shaped; ninth sternum with a narrow, deep concave posterior emargination, membrane not spiculate. Basistyle with ventral root long and slender; subequal in length to slightly stouter parallel sided dorsal root.

Paramere tapering gradually to a fine bare point, curved outwardly, then ventrally and inwardly in a semicircle; paramere slender except abruptly swollen just basad of midlength, narrowly joined to anteriorly directed accessory process. Aedeagus with a moderately long, nearly parallel sided, nearly truncate median posterior process, lateral arms moderately long, arcuate.

COMMENT. The paramere is unusual in being very strongly swollen just basad of midlength.

PUPA. One specimen seen, det. W. W. Wirth, June 1955, Jones no. 3119. Respiratory horn uniformly pale yellow, concolorous with rest of pupa, with 5 apical and 3 lateral spiracular openings, no transverse convolutions, few spines; widest near base, L/W ratio 6.3. Operculum with much of surface covered with weak papillae, a few blunt spines along lateral margin on posterior third-quarter; *am* setae stout, about one-third as long as maximum width of operculum. The *d* tubercles slightly out of line, 1 and 2 a little closer together than 2 and 3, setae 1 and 2 long, overlapping; thoracic surface between and adjacent to tubercles with very weak papillae, nearly smooth.

Abdomen with fine spines confined mostly to anterior margins of segments, sparse elsewhere; *lpm* tubercles elongate, bifid; last segment with a patch of scales on disc; caudal apicolateral processes with scales, apical half slightly darkened, directed posteriorly at an angle of about 20 degrees to the longitudinal axis of the body.

COMMENT. This specimen was cleared in KOH and may be lighter than normal. It matches Fox's (1942) description and figures of respiratory horn and anal segment, except that it is lighter and has fewer scales.

LARVA. Unknown.

DISTRIBUTION. Md., Va., Fla., N. Y.

New York State Records (first records from State)

Suffolk County, Flanders, Maple Swamp, June 19, 1963, 1 ♀ in LT, coll. R. Means; South Side Country Club, June 20, 1963, 1 ♂, coll. R. Means.

BIOLOGY. *Seasonal distribution*. Beck (1956) collected adults in February and March in Florida and noted that the period of abundance is short. The type material was collected May 19 and 25 in

Maryland (Root & Hoffman, 1937). Foote & Pratt (1954) record it in May from Virginia.

Breeding sites. The type material, reared from pupae, was collected in a cattail marsh at Bay Shore near Baltimore, Md. Specifically an inlet of Chesapeake Bay cut off by a railroad embankment, containing a mixture of fresh and brackish water.

Feeding habits. Unknown. The well developed proboscis, mandibular teeth, and tormae suggest that it is haematophagus. The presence of sensilla on all of the flagellomeres suggest that it is ornithophilic.

Culicoides obsoletus (Meigen)
Figures 49, 87, 124, 161, 205, 234

Culicoides obsoletus (Meigen) : Jamnback & Wirth, 1963 : 188-189, figures 2, 7, 9, 15, 19, 23, 27, 34, 38, 42 (♂, ♀, pupa, larva). *Culicoides* sp. nr. *obsoletus* (Meigen) : Jones, 1961a : 730, 733, figures 4-6 (pupa).

FEMALE. Eyes contiguous; without superior transverse suture. Proboscis long, P/H ratio 0.81(0.80-0.83, n=8). Mandible with 13.4(11-15, n=4) well developed teeth. Flagellomere length ratios 10/8/8/8/8/8/9/-/13/13/14/15/23, AR=1.04(1.00-1.06); sensillar pattern 3, 11-15. Third segment of maxillary palp greatly swollen, L/W ratio 2.24(1.83-2.33, n=7) (occasionally only slightly swollen or moderately as in *sanguisuga*), sensory pit shallow with small opening.

Wing length 1.03(0.85-1.16) : with distal half of second radial cell included in light spot, and other light spots as shown in figure 49; macrotrichia sparse and largely confined to wing apex; vein M_{3+4} often with more than eight macrotrichia and cell M_4 often with more than 4 macrotrichia excluding those bordering the margin. Legs without distinct pale bands; with 5 hind tibial spines, the first longest.

Two equal, moderately to darkly pigmented, subelliptical spermathecae with a maximum width of 37(33-41) and 35(32-39) microns respectively; neck short to very short, slightly tapered.

COMMENT. This species can be distinguished with fair assurance from *chiopterus* and *sanguisuga* by the larger size, darker thorax, well-marked wing with more macrotrichia, and by the more swollen palp.

MALE TERMINALIA. Very similar to *sanguisuga* except: Median cleft on posterior margin of ninth sternite not so open, posterior corners often touching. Tips of parameres with microscopic hairs. Median posterior process of aedeagus short, rounded apically, sides not spinulose; lateral arms beside process sloping anterolaterally then curved anteriorly; lateral arms longer than in *sanguisuga*.

PUPA. Respiratory horn pale yellow with basal quarter clouded with light brown, sometimes very faint, with 3.6(3-5) apical and 4 lateral spiracular openings; horn without spines, slightly narrowed medially, widest near base, L/W ratio 5.3(4.5-6.6). Operculum with very long hairlike spines confined to lateral margins and disc as indicated in figure 234; *am* setae long and slender, more than 0.6 as long as maximum width of operculum. The *d* setae and tubercles as in *sanguisuga*; thoracic surface between and adjacent to tubercles nearly smooth.

Abdomen as in *sanguisuga*.

COMMENT. In addition to differences in pigmentation of the respiratory horn, the operculum of *obsoletus* differs from *sanguisuga* and *chiopterus* in having 11.2(9-13, n=17) long spines along each margin with 3-6 short spines extending along the margin posterior to the long spines. *Sanguisuga* has 8.8(6-12, n=18) of the long spines and lacks the short ones. *Chiopterus* has 13.6(11-16, n=17) of these long marginal spines and does not have short marginal spines.

FOURTH INSTAR LARVA. Dorsal head length 137(125-147, n=6) microns. Comb with 6(n=1) teeth on each side; total comb width 19(n=1) microns.

Thoracic pigmentation as in *sanguisuga*.

COMMENT. The larvae of *obsoletus*, *sanguisuga*, and *chiopterus* can be distinguished by differences in the head length (see key).

DISTRIBUTION. The information cited here was taken from Jamnback & Wirth (1963). "Eurasia, North Africa; eastern North America extending northward into Ontario and Quebec and southward into Tennessee; distribution in western North America is not clear, but we have tentatively identified this species as fairly abundant in light trap collections westward to Alberta and British Columbia, and as far south as Colorado, Oklahoma and Northern California." In eastern North America, it has been recorded from Conn., Ind., Me., Md., Mass., Mich., N. Y., N. C., Ohio, Ont., Pa., Que., Tenn., Va., W. Va., and Wis.

In New York State, Jamnback & Wirth (1963) recorded it from Essex, Genesee, Hamilton and Herkimer Counties. Since that time it has been collected in Albany, Cattaraugus, Chautauqua, Erie, Franklin, Lewis, Livingston, St. Lawrence, Tompkins and Washington Counties.

BIOLOGY. *Seasonal distribution.* Reared *obsoletus* adults have emerged from May to August and wild adults have been collected from May into September in the Adirondack Mountains of New York State. The presence of full grown larvae in early May in this area indicates that the larvae overwinter. The pupal period is 5($n=4$) days. In one instance when eggs laid between July 1 and July 7, 1960, were placed in a clay pot containing beech leaves, and cold conditioned for about a month in a vegetable cellar, then brought into the laboratory, a female emerged on February 21, 1961. When examined after death on March 3, the abdomen was found to be filled with fully developed oöcytes indicating that the first oviposition is autogenous.

Breeding sites. In North America specimens have been reared from moist straw, a pile of decaying spruce needles mixed with twigs and wood chips, from soil polluted with chicken or horse manure, from decaying cornstalks, and from piles of mixed bedding and cow manure. In Britain, Kettle & Lawson (1952) found it breeding primarily in sphagnum bogs and marshes.

Feeding habits. *Obsoletus* has been collected feeding on man, horses, and cattle. Because of its habit of breeding in polluted soil or decaying organic matter, it may be an important pest in farm areas. The closely related *sanguisuga* is more common in the deciduous forest areas where it breeds.

Culicoides piliferus Root & Hoffman
Figures 50, 88, 125, 162, 181, 206, 235

Culicoides piliferus Root & Hoffman: Wirth & Hubert, 1962: 185-186, figures 1a-g, 11 (♂, ♀).

FEMALE. Eyes narrowly separated. Proboscis intermediate to long, P/H ratio 0.74(0.69-0.82). Mandible with 13.1(12-14) well developed teeth. Flagellomere length ratios 11/7/6/7/7/7/7/7/-/18/21/21/22/31, AR=1.93(1.86-2.08); sensillar pattern 3, 5, 7, (8), 9, (10), 11-15 (all 5 specimens measured had one or more extra segments with sensilla). Third segment of maxillary palp greatly swollen, L/W ratio 2.03(1.90-2.24), sensory pit shallow with large opening.

Wing length 1.30(1.25-1.38)mm., with distinct typical *piliferus* group pale markings as indicated in figure 50; macrotrichia moder-

ately abundant, mostly on apical half. Legs with faint pale bands; with 4 hind tibial spines, the second one usually longest or subequal to first.

Two slightly unequal, heavily pigmented, long subelliptical spermathecae with a maximum width of 42(42-44) and 37(35-38) microns respectively; neck very short parallel sided or absent.

MALE TERMINALIA. Ninth tergum with slender apicolateral processes which would not touch if directed medially; median notch V-shaped; ninth sternum with narrow deep concave posterior emargination, membrane not spiculate. Basistyle with ventral root "boat-hook" shaped, dorsal root long, slender and parallel sided.

Paramere gradually tapering to a fine point, with a row of delicate spines near tip, curved outwardly, ventrally, and posteriorly in a semicircle; paramere slender except at base which is enlarged. Aedeagus with a long parallel sided median posterior process, truncate and ridged apically, lateral arms slender arcuate with a long flange at base.

COMMENT. Reared males of *bickleyi* and *jamnbacki* could not be distinguished from those of *piliferus*. Wirth and Hubert (1962) noted that the male genitalia of all of the *piliferus* group species are so similar that no positive identification of the males could be made; species included in this group occurring in New York State are: *alexanderi*, *bickleyi*, *denticulatus*, *downesi*, *jamnbacki*, *piliferus*, *pseudopiliferus*, *scanloni*, *testudinalis*.

PUPA. Respiratory horn uniformly brown, darker than rest of pelt with 4(3-5) apical and 2.8(2-3, n=4) lateral spiracular openings; median two-thirds with well developed spines, lacking transverse convolutions but narrowed medially, widest near base, L/W ratio 7.2(6.3-7.9, n=4). Operculum with spines mostly confined to lateral margins with few on disc, papillate posteriorly and on disc; *am* setae moderately long, almost half as long as maximum width of operculum. The *d* tubercles 1-3 in line, 1 and 2 closer than 2 and 3, setae 1 and 2 moderately long overlapping or almost overlapping; thoracic surface between and adjacent to tubercles nearly smooth.

Abdomen with fine spines most abundant near anterior margins of segments but moderately abundant scattered over segments. The *lpm* tubercles usually with a single point and a subapical seta, sometimes with a poorly developed second point. Last segment with a patch of spines on disc; caudal apicolateral processes with small scales and apical quarter darkened, directed posteriorly at an angle of 30 degrees or less to the longitudinal axis of the body.

COMMENT. The pupae of *piliferus* gp. species *bickleyi*, *jamnbacki*, and *piliferus* are rather similar. All have opercula with some spines,

these mostly confined to the lateral margins but covered mostly with papillae which appear to be precursors to spines. The *d* tubercles 1 and 2 of *piliferus* form a well-developed blunt dorsal apical point while those of *jamnbacki* and *bickleyi* are rounded or, at most, with a very weakly developed point. The *lpm* tubercles of *piliferus* usually have a single blunt point and a subapical spine while *jamnbacki* and *bickleyi* usually have bifid points. The respiratory horn of *piliferus* is relatively longer and narrower than those of the other two species and is distinctly narrowed medially, unlike the other two.

FOURTH INSTAR LARVA. One poorly mounted larval head capsule was available for examination. The larval head length (some estimation was necessary) was about 180 microns. Comb with 7 unequal teeth on each half; total comb width 23 microns; head capsule yellow.

DISTRIBUTION. Although *piliferus* was described in 1937, the original type series included more than one species. Until the redescription and restriction of the species by Wirth & Hubert in 1962 it was the general practice to include all species with the typical *piliferus* group wing pattern in the species *piliferus*. *Piliferus* ss. has been collected in Conn., Md., Mass., N. Y., Ont., Que., Va., and Wis. (Wirth & Hubert, 1962).

New York State Records

Albany County, Altamont, Quay Rd., stream margin, July 1, 1963—5; reared larva, pupated July 2, ♂ emerged July 7; Delmar, Game Farm, July 5, 1963, 2 ♀♀ in LT; E. Berne, Jamnback's June 20, July 1, 27, Aug. 13, and Aug. 28 all 1963, 1 ♀ on each night in LT (except July 27—2 ♀♀), coll. HAJ.

Cattaraugus County, Allegany State Park, France Brook margin June 3, 1963, reared 6 ♀♀, coll. WWW.

Essex County, Newcomb, Hamilton-Essex Line, Rte. 28N, June 4-Aug. 30, 12 ♀♀ in LT; same location, June 3, 1959-8, reared larva, pupated June 9, ♀ emerged June 13; same location reared pupa June 1, 1959-5, pupa found June 3, ♀ emerged June 5; June 12, 1959, 1 ♀ in LT; June 26, 1959, 1 ♀ in LT, coll. HAJ.

Hamilton County, Blue Mountain L., Stanton place, reared larva, pupated June 1, ♀ emerged June 5; Salmon R. July 24, 1960, 1 ♀ in LT; Aug. 5, 1960, 1 ♀ in LT. Sphagnum Bog, June 10, June 17, and July 19, all 1960, 1 ♀ each night in LT; July 29, 1959, 1 ♀ in LT, coll. HAJ.

Livingston County, Letchworth State Park, June 10-14, 1963, 2 ♀♀ in LT, coll. WWW.

Suffolk County, Timber Point, July 16, 1953, 2 ♀♀ in LT; Mastic Beach, July 2-5, 1953, 1 ♀ in LT; Quogue, April 29, 1957—2, 1 ♂ in Berlese funnel, coll. HAJ.

Tompkins County, Ithaca, Ellis Hollow, June 19, 1963, 7 ♀♀; same location July 2, 1963, 3 ♀♀; same location June 23-24, 1963, 1 ♀, all in LT; same location, June 1963, 1 ♂ and 23 ♀♀, coll. C. O. Berg.

Washington County, Cambridge, Fish hatchery, June 21-25, 1963, 1 ♀; same location July 1-5, 1963, 1 ♀, both in LT, coll. HAJ.

BIOLOGY. *Seasonal distribution.* *Piliferus* adults have been collected mostly between June and August. Reared larvae pupated in June or July, suggesting that this species appears somewhat later in the season than others in the *piliferus* group which typically are the first species to appear as adults in the spring, e.g., *alexanderi*, *bickleyi*, *denticulatus*, *jamnbacki*, *scanloni*, *testudinalis*, *utowana*.

Breeding sites. We have reared *piliferus* larvae or pupae from six sites. All bordered or were close to small streams either in woodland or open marsh. The substrate in each case was a soft or oozing type media i.e., soft mud, or mud with grass roots, or a mixture of sand and silt at the edge of a small stream.

Feeding habits. Unknown except for one record biting man (Wirth & Hubert, 1962). The large number of antennal sensilla and fairly long proboscis suggest that it may be ornithophilic.

Culicoides pseudopiliferus Wirth & Hubert

Figures 51, 89, 126, 163, 207, 236, 258

Culicoides pseudopiliferus Wirth & Hubert, 1962: 189-190, figures 5a-g (♂, ♀).

FEMALE. Eyes broadly separated. Proboscis long, P/H ratio 0.90 (0.88-0.93, n=3). Mandible with 16.3 (16-17, n=3) well developed teeth. Flagellomere length ratios 12/8/8/8/8/8/8/8/-/15/15/17/17/23, AR=1.15 (1.15-1.17, n=3), sensillar pattern 3, 5, 7, 9, 11, 13-15. Third segment of maxillary palp slightly to moderately swollen, L/W ratio 2.94 (2.67-3.14, n=3), sensory pit shallow with small opening.

Wing length 1.22($n=2$)mm., with wing spots very distinct in typical *piliferus* group pattern; macrotrichia abundant. Legs with faint pale bands; with four hind tibial spines, the second longest.

Two unequal, heavily pigmented, subelliptical spermathecae with a maximum width of 39-41 and 53-56($n=2$) microns respectively; neck very short parallel sided.

COMMENT. A dark brown species very similar to *testudinalis*; differing mainly in having a more distinct wing pattern, a slightly less swollen third maxillary palp, and sensilla on antennomere 11.

MALE. Closely resembles *piliferus*.

PUPA. Two specimens seen. Respiratory horn and rest of pelt dark brown with 8-9 apical and 2 lateral spiracular openings; not narrowed or convoluted near middle, basal three-quarters, except extreme base densely covered with spines, L/W ratio 4.8-5.7. Operculum with short blunt spines along both lateral margins, extending far back, rest of operculum covered with short blunt spines and papillae; *d* tubercles 1-3 in line, 1 and 2 closer than 2 and 3, setae 1 and 2 moderately short, not overlapping, stout; area between *d* tubercles papillate.

Abdomen with fine spines abundant, scattered over segments. The *lpm* tubercles usually bifid (sometimes with one fine apical point). Last segment with a patch of spines on disc; caudal apicolateral processes with small spines present and tip darkened, directed posteriorly almost parallel to longitudinal axis of body.

LARVA. Unknown.

DISTRIBUTION. *Pseudopiliferus* was described in 1962 by Wirth & Hubert who recorded it from Ala., Conn., Md., Mass., Mich., Ont., S. C., Va., Wis. Except for the New York State records, the information below is taken from their study.

New York State Records (first records from State)

Cattaraugus County, Allegany State Park, May 28-June 3, 1963, 1 ♀ in LT, coll. WWW.

Chautauqua County, Sinclairville, muddy brook, May 31, 1963, 1 ♂ and 13 ♀ ♀, coll. WWW.

Lewis County, Watson, Pine Grove, June 22, 1963, 1 ♀ in LT, coll. WWW.

Schuyler County, Kayutah Lake margin, June 17, 1963, 1 ♀ swept, coll. WWW.

Suffolk County, Montauk, May 24, 1963, small pond, reared 2 ♂ ♂ and 1 ♀ (with pupal pelts), coll. WWW.

Wyoming County, Portageville, Genesee River margin, June 13, 1963, 2 ♀♀ swept; Warsaw, Oatka Creek margin, June 11, 1963, 2 ♀♀ swept, coll. WWW.

BIOLOGY. *Seasonal distribution.* A spring and early summer species, as are most species in the *piliferus* gp.

Breeding sites. Muddy habitats.

Feeding habits. Unknown. The well developed mouthparts suggest that it is haematophagus; the large number of antennomeres with sensilla, that it is ornithophilic.

Culicoides sanguisuga (Coquillett)

Figures 52, 90, 127, 164, 208, 237, 259, 287

Culicoides sanguisuga (Coquillett): Jamnback & Wirth, 1963: 189-191, figures 3, 4, 6, 10, 11, 13, 14, 18, 22, 26, 31, 32, 33, 36, 40, (♂, ♀, pupa, larva).

FEMALE. Eyes contiguous; without superior transverse suture. Proboscis long, P/H ratio 0.90(0.86-0.96, n=12). Mandible with 15.3(14-16, n=12) well developed teeth. Flagellomere length ratios 10/8/8/8/8/8/8/9/-/13/13/14/15/23, AR=1.16(1.12-1.20); sensillar pattern 3, 11-15. Third segment of maxillary palp slightly swollen, L/W ratio 3.00(2.92-3.33, n=9), sensory pit shallow with small opening.

Wing length 0.96(0.87-1.15, n=9)mm., with distal half of second radial cell included in light spot and other light spots as shown in figure 52; macrotrichia sparse and largely confined to wing apex; vein M_{3+4} usually with fewer than 8 macrotrichia and cell M_4 often with fewer than 4 macrotrichia excluding those bordering the margin. Legs without distinct pale bands; with 5 hind tibial spines, the first longest.

Two equal, lightly to moderately pigmented, subelliptical spermathecae with a maximum width of 42(39-45) and 41(38-45) microns respectively; neck short to very short slightly tapered subparallel.

MALE TERMINALIA. Ninth tergum without apicolateral processes; median notch a narrow cleft; ninth sternum with a deep, narrow median cleft on posterior margin, membrane not spiculate. Basistyle with ventral root long and slender, longer than the dorsal root which is strongly tapered near base and parallel sided near the apex.

Paramere gradually tapering to a fine bare distal point, curved inwardly and slightly posteriorly; paramere becoming gradually more swollen posteriorly, with a stout, tapering, outwardly directed flange at base. Aedeagus with a short, concave tipped median posterior process, the sides usually spinulose, lateral arms curving slightly posterolaterally beside median posterior process than recurved anteriorly, arms relatively short, occasionally slightly outcurved at base. PUPA. Respiratory horn uniformly pale yellow, concolorous with rest of pelt, with 3.4(3-4) apical and 4.8(4-5) lateral spiracular openings; horn without spines, slightly narrowed medially, widest near base, L/W ratio 5.0(4.4-5.9). Operculum with very long hairlike spines confined to lateral margins and disc as indicated in figure 237. The *am* setae long and slender, more than 0.7 as long as maximum width of operculum. The *d* tubercles 1 to 3 about in line with 1 and 2 much closer than 2 and 3; the first two setae long and overlapping, unusual in that 2 is more than twice as long as 1, *d* tubercles often with several separate points; thoracic surface between and adjacent to tubercles nearly smooth.

Abdomen with fine spines confined mostly to anterior margins of segments. The *lpm* tubercles with a single point and a subapical seta, last segment with a transverse band of spines across disc; caudal apicolateral processes reduced in size, with scales on inner margin, tips sometimes darkened, directed posteriorly nearly parallel to the longitudinal axis of the body.

COMMENT. *Sanguisuga* and other members of the *obsoletus* group are unique in possessing long hairlike spines on the operculum, *d* seta 2 much longer than seta 1, a transverse band of spines across the disc, and together with *venustus* and *holleusis* possess two long *ad* setae. In *sanguisuga* the longer of the *ad* setae is shorter than, or subequal in length to, the respiratory horn.

FOURTH INSTAR LARVA. Dorsal head length 167(156-175, $n=13$) microns. Comb with 7.6(6-10) teeth on each half; total comb width 23(18-27) microns; head capsule pale yellow.

Each thoracic segment with a lateral pigmented oval spot about half-way between anterior and posterior margins, that on metathorax more elongate than on preceding two segments.

COMMENT. Only larvae in the *obsoletus* group have a pigmented spot on the prothorax about half-way between the anterior and posterior margins. They are distinctive also in having unusually small eyes each made up of a single U-shaped pigmented spot which appears round under low magnification. Other species have larger eyes each made up of two separate pigmented spots, one considerably larger than the other.

DISTRIBUTION. The information cited here was taken from Jamnback & Wirth (1963). "Eastern North America extending northward into Ontario and Quebec, southward into Georgia; westward the species apparently extends to the Pacific coast from California to Alaska."

In eastern North America it has been recorded from Conn., D. C., Ga., Ind., Labrador, Me., Md., Mass., N. H., N. Y., N. C., Ont., Pa., Que., Tenn., Vt., Va., W. Va., and Wis.

In New York State they recorded it from Cattaraugus, Clinton, Essex, Hamilton, Herkimer, Jefferson, and Warren Counties. Since that time it has been collected in Albany, Lewis, Livingston, Orleans, St. Lawrence, Tompkins, and Washington Counties.

BIOLOGY. The information given below was summarized from Jamnback (1961) (as *obsoletus*) and Jamnback & Watthews (1963). *Seasonal distribution.* Adults were present in the Adirondack Mountain region of New York State beginning in late May and reaching a peak between mid-June and early July. After mid-July numbers declined rapidly, and relatively few were present by the end of July, although a few were collected into August. The larvae overwinter and begin pupating about mid-May. The first oviposition (of at least some specimens) is autogenous. Thereafter, a blood meal is required. Females usually lay their eggs 6 to 7 days after a blood meal and the larvae hatch about 5 days thereafter. The first small larvae are found in late June or early July, by early August some of these have grown to their prepupation length of about 4 mm. However, these larvae do not pupate until the following spring. The females are long-lived; wild-caught specimens have survived as long as 51 days when given access to sugar solution. A blood meal alone does not contribute to longevity.

Breeding sites. The typical breeding site of *C. sanguisuga* is highly localized and specific, individual sites covering an area of only a few square feet. It is considerably drier than is typical for the genus and consists of an unusually heavy accumulation of dead leaves, the outermost ones usually dried up and curled, the inner ones flattened and closely appressed with just enough moisture to glisten when the leaves are separated. These conditions most commonly occur in masses of beech leaves (*Fagus grandifolia*). Favorable sites are often found on well-drained slopes where the leaves accumulate in the lee of fallen logs or boulders.

Feeding habits. *Sanguisuga* is an abundant and vicious pest of man in the deciduous forests of the northeastern United States and southeastern Canada. It also has been recorded biting horses, cattle, rabbits, hares, ducks, grouse, blue jays, and white-throated sparrows.

Culicoides scanloni Wirth & Hubert

Figures 53, 91, 128, 165

Culicoides scanloni Wirth & Hubert, 1962: 187-188, figures 3a-g, 12 (♂, ♀).

FEMALE. One specimen examined, eyes narrowly separated. Proboscis moderately long, P/H ratio 0.74. Mandible with 13 well developed, although small teeth. Flagellomere length ratios 10/6/6/6/7/7/7/7/7-/13/15/17/17/23, AR=1.43; sensillar pattern 3, 5, 7, 9-15 (absent on segment 10 on one side). Third segment of maxillary palp greatly swollen, L/W ratio 1.88, sensory pit shallow with a large opening.

Wing length 0.87mm., with distinct *piliferus* group pattern pale spots; macrotrichia sparse to moderately abundant. Legs with faint pale bands; with 4 hind tibial spines, the second one longest.

Two unequal, elliptical, lightly pigmented spermathecae with a maximum width of 26 and 32 microns respectively; necks absent.

COMMENT. This is the smallest species in the *piliferus* group.

MALE, PUPA, LARVA. Not seen.

DISTRIBUTION. *Scanloni* was described in 1962 by Wirth & Hubert who recorded it from Ala., Conn., Fla., Md., Mass., S. C., and Va. Except for the New York State records, the information cited below is taken from their publication.

New York State Records (first records from State)

Suffolk County, Eastport, Duck Research Laboratory area, no date, 1 ♀, coll. HAJ.

BIOLOGY. *Seasonal distribution*. Adults have been collected mostly in May and June and a few in July (also March and April in Florida). It appears to be an early spring species as are most other *piliferus* group species.

Breeding sites. Wirth reared this species from pupae collected in an Osumunda fernbog. Otherwise unknown.

Feeding habits. Forty females, many blood-filled, were collected in a chicken house in Connecticut and two females were collected over turkeys in South Carolina (Wirth, 1964). The mandibular dentition is well developed and the antennae have 10 flagellomeres with sensilla suggesting that it is ornithophilic.

Culicoides sphagnumensis Williams

Figures 54, 92, 129, 166

Culicoides sphagnumensis Williams, 1955c: 269-271, figures 1-6 (♀).

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.81 (0.75-0.84). Mandible with 13.6(13-14) well developed teeth. Flagellomere length ratios 13/7/7/7/7/8/8/8/-/23/24/26/28/36, (n=4); AR=1.91(1.83-2.00); sensilla present on all flagellomeres. Third segment of maxillary palp greatly swollen, L/W ratio 2.44 (2.10-2.80), sensory pit shallow with large opening.

Wing length 1.42(1.28-1.50)mm., with a few moderately distinct pale spots as indicated in figure 54; macrotrichia abundant. Legs with faint pale bands; four hind tibial spines with the second usually longest.

One heavily pigmented subelliptical spermatheca with a maximum width of 57(53-63) microns; neck very short parallel sided.

MALE TERMINALIA. We have not seen males of this species. The following description is adapted from Williams (1955c). Ninth tergum with moderately slender apicolateral processes which would not touch if directed medially; median notch broad and shallow, ninth sternum with a broad and shallow concave posterior emargination, membrane not spiculate. Basistyle with ventral root represented only by a slight projection; dorsal root long, strongly tapering.

Paramere tapering to a fine bare point curving inwardly and then outwardly so that the two may cross; paramere slightly swollen at midlength, base broadly joined to anteriorly directed accessory process. Aedeagus with a short, tapering, apically rounded median posterior process and long arcuate lateral arms curved inward and then outwardly near base.

PUPA and LARVA. Unknown.

DISTRIBUTION. Mich., N. Y., Ont., Que.

New York State Records (first records from State)

Essex County, Newcomb, Hamilton-Essex line, Rte. 28N, July 21, 1959, 1 ♀ in LT, coll. HAJ.

Hamilton County, Blue Mountain L., Stanton place, Aug. 21, 1960, 1 ♀ in LT; Salmon River, Aug. 30, 1960, 1 ♀ in LT, coll. HAJ.

Suffolk County, Speonk, Wilcox Duck Farm, Aug. 14, 1962, 1 blood engorged ♀ in LT, coll. R. Means.

BIOLOGY. *Seasonal distribution.* Williams' collections of the type material and our limited data suggest that it is a late summer species with adults present mostly in July and August in the latitude of Michigan and New York State. However, the more extensive collections of Bennett (1960a) in Algonquin Park, Ontario, indicate that it is more abundant from mid-June to the end of June in that area.

Breeding sites. Williams (1955c) collected it from recovery cages over sphagnum mat at the edge of a pond and on a lake shore.

Feeding habits. Fallis & Bennett (1960, 1961a) and Bennett (1960a) have shown that *sphagnumensis* is primarily ornithophilic. Bennett collected *sphagnumensis* in the largest numbers in the forest 5-25 feet in the air feeding on larger birds. He recorded it as abundant on spruce grouse, domestic duck, crow, and flicker, and feeding in lesser numbers on ruffed grouse, grackle, white-throated sparrow, raven, and saw-whet owl. *Sphagnumensis* has been shown to be an intermediate host of the protozoan *Haemoproteus canachites*, a parasite of the spruce grouse (Fallis & Bennett, 1960). In a later study (1961) they incriminated *sphagnumensis* as an intermediate host of *Haemoproteus* parasitic in crows and purple finches.

Culicoides spinosus Root & Hoffman

Figures 55, 93, 130, 167, 209, 238, 260, 275

Culicoides spinosus Root & Hoffman: Foote & Pratt, 1954: 31-32, figures 16, 111 (♂, ♀).

FEMALE. Eyes narrowly separated. Proboscis moderately long, P/H ratio 0.72(0.61-0.82, n=4). Mandible with 14.5(13-16, n=4); well-developed teeth. Flagellomere length ratios 13/9/10/10/11/11/11/11/-/17/17/19/20/28, AR=1.10(1.09-1.11, n=4); sensillar pattern 3, 11-15. Third segment of maxillary palp moderately swollen, L/W ratio 2.57(2.47-2.70, n=3), sensory pit shallow with large opening, some sensoria on palp surface.

Wing length 1.21(1.17-1.23, n=3)mm. (figure 55), with faint to distinct pale spots; macrotrichia moderately abundant, arranged in

linear pattern. Legs without distinct pale bands, four hind tibial spines, the second longest.

Two nearly squal round to elliptical, moderately to heavily pigmented spermathecae with a maximum width of 45 (42-47) and 48 (44-50, $n=4$) microns respectively; neck long slightly tapering.

COMMENT. The reproductive systems of most New York State species with two spermathecae possess both a rudimentary spermatheca and a short sclerotized portion of the common duct called the sclerotized ring. The sclerotized ring is absent only in *loisae*, *melleus*, *spinosus* and *stilobezzioides*.

MALE TERMINALIA. Ninth tergum with long slender apicolateral processes which would touch if directed medially; median notch absent, margin between processes evenly concave or very broadly V-shaped; ninth sternum with a broad, deep concave posterior emargination, membrane not spiculate. Basistyle with ventral root long and slender, basal half tapering; subequal in length to stouter, strongly tapering dorsal root.

Paramere divided near distal end into four subequal pointed tips; paramere narrowed at midlength, swollen toward base which is narrowly joined to anteriorly directed accessory process. Aedeagus with a moderately long median posterior process, rounded apically; lateral arms arcuate, long and slender with a short flange at base.

COMMENT. See *loisae* p. 78.

PUPA. Respiratory horn slightly paler than rest of pelt except darkened apically, with 6.7 (6-7) apical and 1.4 (1-3, $n=3$) lateral spiracular openings; surface on median two-thirds with spines moderately abundant, no transverse convolutions; horn widest near base where it is slightly swollen, L/W ratio 5.1 (4.4-5.5, $n=3$). Operculum with short spines extending far back along lateral margins and moderately abundant on disc; *am* setae stout and moderately long, about 0.4 as long as maximum width of operculum. The *d* tubercles 1-3 in line, about equidistant, setae 1 and 2 short, not overlapping; thoracic surface between and adjacent to tubercles weakly papillate.

Abdomen with spines mostly confined to anterior segment margins but penultimate segment with a distinct mid-dorsal line of spines extending entire segment length, spines less abundant on other segments except last segment with dorsal patch of spines; *lpm* tubercles ridged or weakly bifid; caudal apicolateral processes with spines, darkened at tip; directed posteriorly at an angle of about 30 degrees to the longitudinal axis of the body.

COMMENT. See p. 57.

LARVA. Not seen.

DISTRIBUTION. *Spinusus* is a common species west of the Rocky Mountains and has been recorded from Ala., Fla., Md., Mass., N. C., N. J. (New Brunswick, lake margin, July 12, 1958, reared 1 ♂, coll. WWW.), N. Y., Okla., Ont. (Algonquin Park, marsh, June 8, 1960, reared 1 ♂, coll. WWW.), Tex., Va., W. Va., Wis. (First records for New Jersey, Ontario and West Virginia, see feeding habits.)

New York State Records

Cattaraugus County, Allegany State Park, stream margin, May 28-June 3, 1963, reared 4 ♂♂ with pupal pelts, coll. WWW.

Chautauqua County, Sinclairville, muddy brook edge, May 31, 1963, reared 29 ♂♂ and 4 ♀♀; Bemus Pt., swampy woods, May 31, 1963, 1 ♂; Ivory, grassy puddle, May 31, 1963, reared 1 ♀, coll. WWW.

Genesee County, Batavia (Foote & Pratt, 1954); Bergen Swamp, cedar bog, June 14, 1963, reared 6 ♂♂ and 1 ♀, coll. WWW.

Hamilton County, Blue Mountain L., Mud Pond Outlet, sand bar, June 10, 1960, reared 4 ♂♂ and 1 ♀ with pupal skins, coll. WWW.

Jefferson County, Watertown, Rte. 12, stream beside Reasoner's Garage, stream margin, May 20, 1963—1, 2, 1 ♂ and associated pupa from grass and mud, coll. HAJ.

Lewis County, Watson, Pine grove, June 22, 1963 1 ♀ in LT; Whetstone Gulf, June 20-23, 1963, 1 ♀, coll. WWW.

Livingston County, Letchworth State Park, creek margin, June 13, 1963, reared 3 ♂♂ and 3 ♀♀, coll. WWW.

Monroe County, Braddock Bay, near marsh, June 12, 1963, 1 ♂, coll. WWW.

Orleans County, Albion, Burma Woods, June 11, 1963, 1 ♂, coll. WWW.

Schuyler County, Mecklenburg, creek margin, June 17, 1963, reared 1 ♀; Kayutah Lake margin, June 17, 1963, 1 ♀, coll. WWW.

Tompkins County, Ellis Hollow, June 1963, 9 ♀♀ in LT, coll. C. O. Berg; Freeville, Mud Creek, swamp, June 19, 1963, reared 1 ♂ and 1 ♀ with pupal skins; McLean Reserve, creek margin, June 18, 1963, reared 4 ♂♂ and 1 ♀ with pupal skins, coll. WWW; Ithaca, Buttermilk Falls, stream margin, June 11, 1963—5, reared larva June 11, pupated June 15, ♂ emerged June 19; same collection, reared pupa, June 11, ♂ emerged June 15, from grass roots and clay soil, saturated, coll. HAJ.

BIOLOGY. *Seasonal distribution.* Extensive collecting in Texas (Wirth & Bottimer, 1956) indicates *spinusus* adults are present in

the early spring (April-May) and again in August, suggesting two generations per year in this area. Jones (1961a) collected pupae in May and August in Wisconsin. Elsewhere adults have been collected mostly in April, May, and June (Coher *et al.*, 1955; Snow *et al.*, 1957; Foote & Pratt, 1954). The presence of pupae in the early spring in New York State suggests that it probably overwinters in the larval stage.

Breeding sites. *Spinusus* larvae or pupae have been collected mostly from the margins of streams, puddles or ponds usually from a substrate of mud or sand or a combination of the two, in our collections often mixed with grass roots (Wirth & Bottimer, 1956; Snow *et al.*, 1957; Foote & Pratt, 1954; Jones 1961b).

Feeding habits. Snow (1955), and Snow *et al.* (1957), recorded this species feeding on man and noted that it was most abundant in the spring, feeding during the day in the forest canopy. Wirth (unpublished) gives two additional records of its biting man; one from Rock Springs, Florida, November 1951, coll. W. McDuffie; the other from Cranberry Glades, West Virginia, June 16, 1955, coll. WWW. Its hosts other than man are not known. The sensillar pattern suggests that it may feed primarily on mammals.

Culicoides stellifer (Coquillett)

Figures 56, 94, 131, 168, 210, 239, 261, 273, 288

Culicoides stellifer (Coquillett): Fox, 1942: 419, figures 15, 21 (pupa); Forattini, 1957: 421-426, figures 98a-h, 99 (♂, ♀, pupa).

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.78(0.76-0.80). Mandible with 13.6(12-15) well developed teeth. Flagellomere length ratios 13/8/8/9/9/10/10/10/-/13/14/15/16/23, AR=0.98(0.91-1.06); sensillar pattern 3, (6), (7), 8-10. Third segment of maxillary palp moderately swollen, L/W ratio 2.52(2.43-2.62), sensory pit shallow with large opening.

Wing length 1.06 (1.04-1.11) mm., with distinct pale spots as shown in figure 56, 2 pale spots in cell R_5 often joined; macrotrichia sparse to moderately abundant mostly on distal half of wing. Legs with distinct pale bands; five hind tibial spines with the second usually longest.

Two subequal, oval to subelliptical, lightly to moderately pigmented spermathecae, with a maximum width of 37(35-39) and 34(33-35) microns respectively, neck long, parallel sided.

MALE TERMINALIA. Ninth tergum with slender apicolateral processes which would not touch if directed medially; median notch a broad V-shaped cleft; ninth sternum with a narrow concave posterior emargination, membrane not spiculate. Basistyle with ventral root "boat-hook" shaped; dorsal root long slender, parallel sided.

Paramere ending in a broad comb with about nine teeth, curved outwardly, ventrally, and posteriorly in a semicircle; paramere at most barely swollen near midlength, margins sinuate, not swollen posteriorly, base not swollen. Aedeagus with median posterior process short truncate, ridged at apex; lateral arms long and slender with a long flange at base.

PUPA. Respiratory horn concolorous with rest of pelt, darkened apically with 4.2(4-5) apical and 3.4(3-4) lateral spiracular openings, scale-like spines moderately abundant on basal two-thirds (except near base), scales giving transverse convoluted wrinkled appearance, widest near base, L/W ratio 6.3(5.2-8.3). Operculum with short blunt spines confined to disc and margins, extending posteriorly along margins beyond disc; *am* setae short, about one-third as long as maximum width of operculum. The *d* tubercles 1-3 in line, 1 and 2 slightly closer than 2 and 3, seta 1 and 2 moderately long, not overlapping; thoracic surface between and adjacent to tubercles nearly smooth.

Abdomen with fine spines confined mostly to anterior margins of segments. The *lpm* tubercles bifid with unusually long tapering, fine points. Last segment with a patch of spines on disc, caudal apicolateral processes with spines, apical quarter darkened, directed laterally at an angle of 10 to 45 degrees to the longitudinal axis of the body.

COMMENT. The description of *stellifer* pupae agrees in many details with that of *furens*. The two can readily be distinguished by the short spines on the operculum of *stellifer* (long spines for *furens*) and the presence of a patch of spines on the last abdominal segment of *stellifer* (absent on that of *furens*).

FOURTH INSTAR LARVA. Frontoclypeus length 136(129-146) microns. Comb with 7.8(7-8) unequal teeth on each half; total comb width 22(20-23) microns; head capsule pale yellow.

A glistening white larva with thorax unpigmented except for very faint lateral spots on meso- and metathorax.

DISTRIBUTION. *Stellifer* is a common and widely distributed species which has been recorded from the east to west coasts of the United States, and from Canada to Mexico, Trinidad and Venezuela.

North of Mexico it has been recorded from Ala., Ariz., Calif., Conn., Colo., Del., D. C., Fla., Ga., Ill., Kan., Ky., La., Md., Mass., Mich., Miss., Neb., N. M., N. Y., N. C., Ohio, Okla., Ont., Pa., S. C., Tenn., Tex., Utah, Va., Wis.

New York State Records

Albany County, Delmar, Game Farm, June 29-July 5, 1963, 1 ♂ and 8 ♀ ♀ in LT; E. Berne, Jamnback's, July 1, 1963, 1 ♂ in LT; same location, June 23, 1963-1, reared 2 larvae, pupated June 28, June 30, 1 ♀ emerged July 5; same location, June 24, 1963—1, reared pupa, ♀ emerged June 26; same location, June 24, 1963—4, reared larva, pupated July 1, ♂ emerged July 5; same location, June 26, 1963-3, reared 4 larvae, 3 pupated July 1, July 2, 2 ♂ ♂ emerged July 7; same location, July 29, 1963, reared pupa, ♀ emerged August 1; Berne, margin Fawn Lake, June 18, 1963-9, reared larva, pupated June 20, ♀ emerged June ?; New Salem, margin Vly Creek, June 13, 1963-6, reared 3 larvae, 2 pupated June 20, 22, 1 ♂ and 1 ♀ emerged June ?; same collection, reared fresh pupa, ♂ emerged June 22; same location, June 20, 1963-4, reared 2 larvae, 1 pupated June 27, ♂ emerged July 2; same location, June 29, 1963—1, reared larva, pupated July 1, ♂ emerged July 5, coll. HAJ; Slingerlands, July 13-17, 1963, 2 ♀ ♀ in LT, coll. DL Collins.

Genesee County, Bergen Swamp, cedar bog, June 14, 1963, reared 1 ♂, coll. WWW.

Hamilton County, Speculator (Foote & Pratt, 1954).

Lewis County, Watson, Pine grove, June 22 1963, 1 ♀ in LT, coll. WWW.

Schuyler County, Mecklenburg, creek margin, June 17, 1963, reared 1 ♀ coll. WWW.

Suffolk County, Mastic Beach, July 3, 1953, 1 ♀ in LT; North Sea, margin Big Fresh Pond Outlet, May 31, 1957—1, reared larva, pupated June 5, ♂ emerged June 10; same location, June 9, 1957-1, 1 ♀ in Berlese funnel sample; same location, June 11, 1957, 3 ♂ ♂ and 1 ♀ in Berlese funnel sample; same location, June 27, 1957, reared pupa with larval skin attached, male emerged July 3, coll. HAJ; same location, June 12, 1963, 2 ♂ ♂ in LT, coll. R. Means.

Tompkins County, Ithaca, Ellis Hollow, June 19, 1963, 1 ♂ and 1 ♀ in LT; same location, June 15, 1963, 6 ♀ ♀ in LT, coll. C. O. Berg.

Washington County, Cambridge, Fish hatchery, June 21-25, 1963, 2 ♀ ♀ in LT; same location, stream margin, June 21, 1963—1,

reared 2 larvae, 1 pupated July 1, ♀ emerged July ?; same collection, reared pupa, ♂ emerged June 28; same location, July 2, 1963—5, 6, reared 2 larvae, pupated July 9, July 11, 1 ♀ emerged July 15; same collection, reared pupa, ♂ emerged July 5; same location July 11, 1963—8, reared 3 larvae, 2 pupated July 17, 1 ♂ and 1 ♀ emerged July 20; Rte. 372, cattail marsh beside road, June 25, 1963—2, reared 3 larvae, 2 pupated June 29, 1 ♀ emerged July 3, coll. HAJ

BIOLOGY. *Seasonal distribution.* *Stellifer* adults reached peak abundance in April and May and again in August in Texas (Wirth & Blanton, 1956). Further north in the Tennessee Valley area, Snow *et al.* (1957) found that they reached peak levels in June and July although they are present from April into October. Williams (1955b) and James (1943) found that they were most abundant in July and early August in Michigan and Colorado respectively, while Lewis (1959) collected it between June 23 and September 10 in Connecticut. In New York State, adults were most commonly collected in early July. The appearance of large numbers of very small *Culicoides* larvae in late April and early May (long before the species involved are collected on the wing), their gradual increase in size during May and June, and the pupation and emergence of *C. stellifer* and *C. crepuscularis* adults in late June and early July lead us to suspect that these species may overwinter as eggs.

Breeding sites. Our rearing data as well as that of many other workers (Williams, 1955a; Wirth & Bottimer, 1956; Snow *et al.*, 1957; Murray, 1957, and Jones, 1961) indicate that *stellifer* breeds mainly along the margins of streams, ponds, or pools either in bare mud or mud and soil with grass roots intertwined.

Feeding habits. Although we have not collected this species feeding, earlier workers (Pratt, 1907; Malloch, 1915; Hoffman, 1925; Root & Hoffman, 1937; and Murray, 1957) have recorded it biting man. Snow *et al.* (1957) state that specimens collected biting man in the Tennessee Valley and identified as *stellifer*, proved to be *paraensis*. In light of this, any specimens in the northeast identified as *stellifer*, and collected while biting man, should be reexamined. Characters distinguishing the two species are given by Forattini (1957) and a description of *paraensis* given by Wirth & Blanton (1959). In *stellifer* the pale spot in cell M_{3+4} forms an irregular semicircle with the widest portion at the wing margin while in *paraensis* the spot is round and complete, not touching the margin of the wing.

Culicoides stilobezzioides Foote & Pratt

Figures 57, 95, 132, 169

Culicoides stilobezzioides Foote & Pratt, 1954: 33, figure 125 (♂); Jones, 1956: 33, figure 11 (♀).

FEMALE. Eyes narrowly separated. Proboscis of intermediate length, P/H ratio 0.69(0.67-0.71, n=4). Mandibles with 13.3 (11-15, n=3) well developed teeth. Flagellomere length ratios 13/8/8/8/8/8/9/9/-/23/25/26/26/36, AR=1.87(1.65-2.13, n=4); sensillar pattern 3-10(n=4). Third segment of maxillary palp greatly swollen L/W ratio 2.13(2.00-2.23, n=4), with deep sensory pit having a moderately large opening.

Wing length 1.54(1.53-1.55, n=3)mm., with no pale spots; macrotrichia abundant over most of wing. Legs without distinct pale bands; hind tibial spines 5 (one of 4 females had 6 spines) with the second longest.

Two unequal, oval, moderately to well pigmented spermathecae, at widest 49(48-51) and 42(39-44, n=3) microns respectively, neck short tapering. Unique heavily sclerotized internal processes present between the spermatheca and copulatory bursa.

COMMENT. The reproductive systems of most New York State species with two spermathecae possess both a rudimentary spermatheca and a short sclerotized portion of the common duct called the sclerotized ring. The ring was absent in *stilobezzioides*, *loisae*, *melleus* and *spinosus*.

MALE TERMINALIA. Three specimens seen. Ninth tergum strongly tapered, with long, slender apicolateral processes which would touch if directed medially; median notch a broad shallow depression; ninth sternite with a slight median concave emargination, membrane not spiculate. Basistyle with ventral and dorsal roots long and moderately stout, parallel sided similar in general appearance.

Paramere gradually tapering to a stout point, bearing a row of about 5 long hairs near tip, distal portion of paramere curved outwardly ventrally and posteriorly, in a semicircle; paramere not swollen at midlength, base swollen, simple. Aedeagus unique in having median posterior process present only as a concave area between the two lateral arms (when viewed from ventral aspect; the process extends ventrally for a short distance). Lateral arms extending laterally and posteriorly so that the bases are widely separated.

COMMENT. The male terminalia of *stilobezzioides* is strikingly different from that of any other New York State species.

PUPA and LARVA. Unknown.

DISTRIBUTION. Minn., (Itaska State Park, May 1954, in LT, coll. A. R. Barr, NYSM coll.), N. Y., Ont., Wis., (First state record for Minnesota.)

New York State Records

Essex County, Newcomb, Hamilton-Essex Line, Rte. 28N, June 12, 1959, 1 ♀ in LT, coll. HAJ.

Lewis County, Whetstone Gulf, June 20-23, 1963, 1 ♂, coll. WWW.

St. Lawrence County, Cranberry Lake, June 26, 1963, 1 ♀ biting man, coll. WWW.

Tompkins County, Ithaca, June, no other collection data, 2 ♂ ♂ (Foote & Pratt, 1954); Ellis Hollow, June 19, 1963, 2 ♀ ♀ and 1 ♂ in LT, coll. C. O. Berg.

BIOLOGY. *Seasonal distribution*. The 8 adult *stilobezzioides* from New York State, and the large series of specimens from Wisconsin, were all collected in June. Bennett (1960a) gave the period of maximum abundance as June 18-30 in Algonquin Park, Ontario. The specimen from Minnesota was collected in May 1954.

Breeding sites. Unknown.

Feeding habits. Fallis & Bennett (1960, 1961a), Bennett & Fallis (1960) and Bennett (1960) reported that this species is strongly ornithophilic. They have collected it feeding on ruffed grouse, spruce grouse, purple finch, crow, saw-whet owl, flicker, white-throated sparrow, and blue jay. It is similar to *sphagnumensis* in being found in the largest numbers in the forest at a height of 5-25 feet and being most active about dusk. Fallis & Bennett (1961) have incriminated *stilobezzioides* as a possible intermediate host of a protozoan (*Haemoproteus*) parasite of the purple finch. There is one record of *stilobezzioides* feeding on man (see above).

Culicoides testudinalis Wirth & Hubert

Figures 58, 96, 133, 170, 211, 262

Culicoides testudinalis Wirth & Hubert, 1962: 191-192, figures 7, 15 (♀).

FEMALE. Eyes broadly separated. Proboscis long, P/H ratio 0.78 (0.75-0.81). Mandible with 16(15-17) well developed teeth. Flagellomere length ratios 13/9/9/9/9/9/10/-/15/15/17/18/26, AR=1.15 (1.11-1.21); sensillar pattern 3, 5, 7, 9, 13-15. Third segment of maxillary palp moderately swollen L/W ratio 2.50(2.38-2.58), sensory pit shallow with small to moderate sized opening.

Wing length 1.11(1.08-1.17)mm., with pale spots over r-m cross-vein and just beyond second radial cell distinct, pale spots elsewhere varying from very faint or apparently absent to moderately distinct (typical *piliferus* group pattern); macrotrichia moderately abundant to abundant. Legs without distinct pale bands; with four hind tibial spines, the first or second longest.

Two unequal heavily pigmented subelliptical spermathecae with a maximum width of 42(36-45) and 57(47-63) microns respectively; neck absent or very short parallel sided.

COMMENT. A dark brown species close to *pseudopiliferus*.

MALE. Closely resembles *piliferus*.

PUPA. Two specimens examined. Respiratory horn brown, darker than rest of pupal pelt, with 4 apical and 3-4 lateral spiracular openings; surface on median half with scattered scale-like spines, no transverse convolutions; horn, long slender, widest near base, L/W ratio 7.3-7.7. Operculum of the specimens examined folded over and difficult to see, disc papillate, no spines noted; *am* setae short and stout, less than one-third maximum width of operculum. The *d* tubercles 1-3 in line, 1 and 2 slightly closer than 2 and 3, setae 1 and 2 moderately long, not overlapping; thoracic surface between and adjacent to tubercles weakly papillate.

Abdomen with spines more abundant near anterior margins but scattered over most of the rest of all of the segments; last segment with patch of spines covering most of dorsum; *lpm* tubercles bifid; caudal apicolateral processes with spines, darkened at tip; directed posteriorly at an angle of about 30 degrees to the longitudinal axis of the body.

LARVA. Unknown.

DISTRIBUTION. *Testudinalis* was described in 1962 by Wirth & Hubert who recorded it from Conn., Md., Mass., Pa., Va., and Wis.

Except for the New York State records, the information cited below is taken from their publication.

New York State Records (first records from State)

Tompkins County, Ithaca, Ellis Hollow, June 19, 1963, 7 ♀ ♀ in LT (1 of these blood engorged), coll. C. O. Berg; McLean Reserve, sphagnum bog, June 18, 1963, 20 ♀ ♀ (1 of these blood engorged), coll. WWW; Freeville, Mud Creek Swamp, June 19, 1963, reared 3 ♂ ♂ and 3 ♀ ♀ (with pupal pelts); Danby, Michigan Hollow pond margin, June 18, 1963, 1 ♀, coll. WWW.

BIOLOGY. *Seasonal distribution.* Adults have been collected mostly in May and June and relatively few in July.

Breeding sites. Wirth reared 11 ♀ ♀ from an *Osmunda fern* bog in Virginia. Otherwise unknown.

Feeding habits. Three collectors in three different states record this species feeding on wood turtle, box turtle, and turtle respectively. This is the only species of *Culicoides* in New York State that is known to feed on animals other than birds or mammals.

Culicoides travisi Vargas
Figures 59, 97, 134, 171, 263

Culicoides travisi Vargas: Foote & Pratt, 1954: 33-34, figures 8, 34, 83, 114 (♂, ♀).

Culicoides horneae Foote & Pratt, 1954: 25, figures 27, 37, 121 (♂). **New synonymy.**

FEMALE. Eyes narrowly separated. Proboscis long, P/H ratio 0.81 (0.77-0.82). Mandible with 14.2(13-16) well developed teeth. Flagellomere length ratios 15/9/10/10/11/11/11/11/-/25/25/26/26/35, AR=1.50(1.39-1.68); sensilla present on all flagellomeres. Third segment of maxillary palp moderately swollen, L/W ratio 2.55(2.42-2.65), sensory pit shallow with very large opening.

Wing length 1.42(1.35-1.50)mm., with two distinct pale spots, one over r-m cross-vein the other just distad of second radial cell, other spots on wing faint, often not apparent, almost entirely along margin; macrotrichia abundant over most of wing. Legs with indistinct pale bands; usually 4 hind tibial spines with first or second longest (1 of 6 specimens had 5 spines).

Two subequal moderately to well pigmented pyriform to subelliptical spermathecae with a maximum width of 38(35-41) and 41(38-42) microns respectively, neck absent.

COMMENT. This species superficially resembles *biguttatus*, but may be distinguished by the lack of a tapered neck on the spermatheca and presence of sensilla on all flagellomeres.

MALE TERMINALIA. Ninth tergum with stout apicolateral processes which would barely touch if directed medially; median notch distinct narrow V-shaped; ninth sternum with a broad and deep concave posterior emargination, membrane not spiculate. Basistyle with ventral root long and slender; slightly longer than the stouter gradually tapering dorsal root.

Paramere gradually tapering to a fine bare point, curving outwardly and ventrally in a semicircle; paramere slender at midlength, swollen toward base which is narrowly joined to an anteriorly directed accessory process. Aedeagus with a very long, slender, median posterior process, rounded apically but often bent ventrally at tip so that, in slide mounts, it appears truncate; lateral arms short, arcuate, with a long flange at base.

PUPA. Three pelts examined agree in all details of description with *biguttatus* (except lengths of *d* setae, cf. figures 249 and 263).

LARVA. Two head capsules in poor condition examined. Frontoclypeus length 153-162 microns.

DISTRIBUTION. *Travisi* is widely distributed east of the Mississippi River and has been collected in Fla., Ga., Md., Mass., N. Y., Ohio, Okla., Ont., Pa., and Va.

New York State Records

Albany County, E. Berne, Jamnback's June 20-July 27, 1963, 7 ♂♂ in LT; same location, wet meadow depression, June 26, 1963—1, reared pupa, ♂ emerged June 30; Delmar, State Game Farm, June 29-July 1, 1963, 1 ♀ in LT; New Salem by gas line off Stovepipe Rd., June 13, 1963—8, reared larva June 13, pupated June 18, ♀ emerged June 23, coll. HAJ: Slingerlands, by Normanskill, July 13-17, 1963, 1 ♀ in LT, coll. D. L. Collins.

Cattaraugus County, Allegany State Park, May 28-June 3, 1963, 1 ♂ and 2 ♀♀ in LT, coll. WWW.

Genesee County, Batavia (Foote & Pratt, 1954); Bergen Swamp, June 14, 1963, reared 1 ♂ and 1 ♀ with pupal pelts, coll. WWW.

Lewis County, Watson, Pine grove, June 22, 1963, 2 ♀♀ in LT, coll. WWW.

Livingston County, Letchworth State Park, June 10-14, 1963, 1 ♂ and 3 ♀ ♀ in LT, coll. WWW.

Monroe County, Braddock Bay, near marsh, June 12, 1963, 2 ♂ ♂, coll. WWW.

Orleans County, Albion, Burma Woods, June 19, 1963, 1 ♀, coll. WWW.

Seneca County, 1 mile N. of Taughannock State Park, leaves and detritus besides stream, June 11, 1963—10, reared pupa, ♀ emerged June 18, coll. HAJ.

Steuben County, Bath (Foote & Pratt, 1954).

Tompkins County, Ellis Hollow, June 15-30, 1963, 8 ♂ ♂, 7 ♀ ♀ in LT; June 1963, 19 ♀ ♀ in LT, coll. C. O. Berg.

Washington County, Cambridge, Rte. 372, cattail marsh beside road, June 25, 1963-2 reared larva, June 25, pupated July 2, ♀ emerged July 5; Fish hatchery, June 21-25, 1963, 1 ♀ in LT, coll. HAJ.

BIOLOGY. *Seasonal distribution.* In the Tennessee Valley area, where it was collected in large numbers, *travisi* was present from April to October but most of the specimens were collected in May (Snow *et al.*, 1957). Most of the New York State material was collected in June or early July.

Breeding sites. Two of our reared specimens came from wet grass and mud, one sample taken in a marshy depression of a meadow and the other in a cattail swamp, and a third from leaves and detritus on the margin of a sedimentary rock stream. Elsewhere it has been reared from samples taken by stream and lake margins, leafy pools, and decaying leaves kept moist by a flowing spring (Snow *et al.*, 1957: Jones, 1961a; Williams, 1955a). Wirth's (1951b) record of *travisi* from a treehole habitat in Virginia is in error, the pinned specimen was later identified as *nanus* (Wirth in litt.).

Feeding habits. Snow (1955) collected *travisi* biting man in numbers and found them more abundant at ground level than at an elevation of 75 feet, and at the forest edge rather than in the forest proper. Pickard & Snow (1955) recorded it feeding on both horses and man. Snow *et al.* (1957) collected an engorged female on the inner wall surface of a chicken house. Although we have not found *travisi* feeding on man or other animals in New York State, its long proboscis, well developed mandibular teeth, and strong tormae all indicate that it is haematophagus. The presence of sensilla on all of the flagellomeres suggests that it may be primarily ornithophilic.

Culicoides utowana new species

Figures 60, 98, 135, 172, 212, 240, 264

FEMALE. Eyes moderately separated. Proboscis short, P/H ratio 0.64(0.58-0.71, n=2). Tip of labrum with an unusual and distinct fleshy, tufted distal prolongation. Labial palps slightly swollen. Mandible with 6.7(6-7, n=3) poorly developed teeth.¹¹ Flagellomere length ratios 12/7/8/8/8/8/8/8/12/12/15/17/23 (n=3); AR=1.13(1.08-1.19, n=3); sensillar pattern 3, 11-15. Third segment of maxillary palp short, moderately swollen, L/W ratio 1.75-2.50(n=2); pit moderately deep with large opening.

Wing length 1.07-1.13(n=2)mm., with only the faintest indication of wing spots, or the wing unmarked, macrotrichia moderately abundant over most of wing arranged in a roughly linear fashion. Legs without distinct pale bands; four hind tibial spines with the second longest.

Two very unequal, lightly pigmented, subelliptical spermathecae with a maximum width of 50(50-51) and 41(38-42, n=3) microns respectively; neck absent or very short parallel sided.

COMMENT. *Utowana* differs from *denticulatus* in having very unequal spermathecae with the neck absent or very short parallel sided, in having 4 rather than 5 hind tibial spines, and in having a slightly more swollen third segment of the maxillary palp.

MALE. Unknown.

PUPA. Respiratory horn concolorous with rest of pelt, darkened apically, with 7(6-8, n=3) apical and 2.7(2-3, n=3) lateral spiracular openings; basal third with scale-like spines forming transverse wrinkles; horn widest near base, L/W ratio 5.9(5.6-6.3, n=3). Operculum with short blunt spines along lateral margins, disc with papillae rather than spines (as in *piliferus*); *am* setae short and stout, less than one-third as long as maximum width of operculum. The *d* tubercles 1-3 in line, 1 and 2 closer than 2 and 3, setae 1 and 2 subequal, long, overlapping; thoracic surface between and adjacent to tubercles nearly smooth.

Abdomen without fine spines on segments except near anterior margins. The *lpm* tubercles rounded or ridged; last segment without patch of spines on dorsum; caudal apicolateral processes bare, not darkened at tip, directed laterally at an angle of about 90 degrees from the longitudinal axis of the body.

¹¹ One specimen had several extra, abnormal teeth on one mandible with a total of 9 on one side; the other mandible had 6.

COMMENT. See *denticulatus*.

FOURTH INSTAR LARVA. Dorsal head length 177-184($n=2$) microns. Comb with 8($n=1$) teeth on each half; total comb width 30($n=1$) microns; head capsule pale yellow, frontoclypeus slightly darker.

DISTRIBUTION. N. Y.

New York State Records (first records from State)

Hamilton County, Blue Mountain L., Salmon River Island, partially flooded leaf depression, May 23, 1960—7F, reared 3 larvae, 2 pupated May 26, 1 pupated May 27, 1 ♀ emerged May 31 (HOLOTYPE) and 2 ♀♀ emerged June 2 (PARATYPES). Holotype and two paratypes deposited in the N. Y. State Museum collection.

BIOLOGY. No other details known. Non-haematophagus.

The author is pleased to name this species after Utowana Lake in the Adirondack Mountains. According to the Director of the Adirondack Museum, Dr. R. Inverarity (1961), utowana is the Onondaga Indian word for "big waves" and is pronounced "you-toe-wan-a" with each syllable equally accented.

Culicoides variipennis variipennis (Coquillett)

Figures 61, 99, 136, 173, 182, 213, 241, 265, 276, 289

Culicoides variipennis (Coquillett): Malloch, 1915a: 297-299, Pl. XX, figures 6, 8, 11-15, 17, Pl. XXII, figure 2 (♂, ♀, pupa, larva); Thomsen, 1937: 70, figures 124, 129 (pupa); Fox, 1942: 414, figures 18, 23 (pupa); Wirth, 1952a: 252, figure 32, c, d, f, i, k (pupa, larva).

Culicoides variipennis variipennis (Coquillett): Wirth & Jones, 1957: 12, 14-15, figures 2 (in part), 8a (♂, ♀).

FEMALE. Eyes widely separated. Proboscis long, P/H ratio 0.86 (0.80-0.92, $n=3$). Mandible with 14.7(13-16, $n=3$) well developed teeth. Flagellomere length ratios 17/11/12/13/13/14/13/13/-/14/15/16/17/25, AR=0.80(0.76-0.83, $n=3$); sensillar pattern 3, 8-10. Third segment of maxillary palp slightly swollen, L/W ratio 3.25(3.20-3.33, $n=3$), sensory pit shallow with small opening.

Wing length 1.76(1.71-1.85, $n=3$) mm., with many pale spots as shown in figure 61; macrotrichia moderately abundant, sparse on basal half except in cell M_{3+4} and anal cell. Legs with distinct pale bands near apex of femur and base of tibia, "knees" dark; with 6.7(6-7, $n=3$) hind tibial spines, the second longest.

One C-shaped moderately sclerotized spermatheca with a maximum width of 38(35-42, $n=3$) microns; neck absent.

MALE TERMINALIA. We have not seen males of this species; the following description is adapted from Wirth & Jones (1957). Ninth tergum with short, triangular apicolateral processes which would not touch if directed medially; area between processes evenly concave; ninth sternum with even posterior margin, membrane not spiculate. Basistyle with ventral root indicated only by slight pointed projection, dorsal root long and slender, at most slightly tapered.

Parameres unique in being fused at base, with two short, slender posteriorly directed tips. Aedeagus with median posterior process divided on midline near tip; lateral arms short with a long flange at base.

Since no pupae or larvae of *v. variipennis* were available for study the following descriptions are based on specimens of *v. australis* collected at Boone's Lick Salt Spring, Petersburg, Missouri, on March 11, 1955, coll. P. J. Spangler.

PUPA. Respiratory horn paler than rest of pelt on basal three-fourths, much darkened apically, with 11-14 apical and 3($n=2$) lateral spiracular openings; horn with numerous transverse scale-like spines on median two-thirds giving wrinkled appearance to this area, widest near base, L/W ratio 5.3-5.7($n=2$). Operculum densely covered with short spines on all except posterior fifth; *am* setae short and stout, less than one-quarter as long as maximum width of operculum. The *d* tubercles 1-3 in line, equidistant, with setae 1 and 2 subequal, long but not overlapping, thoracic surface between and adjacent to tubercles coarse with numerous papillae.

Abdomen with fine spines confined mostly to anterior margins of segments. The *lpm* tubercles with stout tapering bifid tips, last segment lacking patch of spines on disc; caudal apicolateral processes lacking spines, apical third of tips darkened, directed at about right angles to longitudinal axis of body.

COMMENT. *Variipennis* pupae can readily be recognized by the unique appearance of the respiratory horn which is very similar to *nubeculosus* as illustrated by Kettle & Lawson (1952).

FOURTH INSTAR LARVA. Frontoclypeus 265(255-285, $n=3$) microns long. Comb with 7-8($n=2$) teeth on each half; total comb

width 28-31 ($n=2$) microns; head capsule brown with two darker brown triangular areas on head posteriorly, as indicated in figure 289; head capsule strongly tapering anteriorly.

Each thoracic segment with patches of reddish brown pigmentation rather evenly distributed over entire segment.

COMMENT. *Variipennis* larvae closely resemble those of the *nubeculosus* group of Europe described by Kettle & Lawson (1952) in having a massive, sclerotized epipharynx apparently adapted for grinding and crushing, unlike the more delicate epipharynx of other species, which appears to be adapted more for sieving and propulsion of the food rather than mastication.

DISTRIBUTION. *Variipennis variipennis* is widely distributed east of the Mississippi River and across the northern United States west to Washington, and across southern Canada. It has been recorded from Ala., B. C., Del., Fla., Ga., Ill., Ind., La., Md., Mich., Minn., Miss., Mo., Mont., Neb., N. H., N. Y., Ohio, Ont., Tenn., Va., Wash., Wis., and Wyo. This is the only subspecies that has been collected in New York State, the four others having a more southern or western distribution. (Wirth & Jones, 1957).

New York State Records

Essex County, Newcomb, Hamilton-Essex Line, Rte. 28N, July 12, 1962, 1 ♀ in LT, coll. HAJ.

Hamilton County, Blue Mountain L., Eagle Nest, September 7, 1959, 1 ♀ in LT, coll. HAJ.

Suffolk County, Montauk Point, in salt marsh August 14, 1961, 1 ♀ biting man, coll. HAJ.

Tompkins County, Ithaca (Foote and Pratt, 1954, as *variipennis* s. l. probably *v. variipennis*).

BIOLOGY. *Seasonal distribution*. Jones (1961) noted that *v. variipennis* unlike the other *variipennis* subspecies, has never been collected in large numbers either as an adult or in the immature stages. Limited adult collections indicate that it may be present as early as January 16 (Georgia) and as late as October 22 (Maryland) (Wirth & Jones, 1957).

Breeding sites. *V. variipennis* has been reared from relatively few sites; from mud and cow manure in a wet area adjacent to a water tank and from the clay-loam margin of a creek. The other subspecies *v. australis* and *v. occidentalis* breed in saline habitats, *v. albertensis* in alkaline habitats and *v. sonorensis* in polluted fresh water. (Wirth & Jones, 1957).

Feeding habits. Price & Hardy (1954) incriminated *variipennis* as a vector of the viral disease "blue-tongue of sheep." Foster *et al.* (1963) have shown that *variipennis* is capable of "biologic transmission" of the virus, i.e., the virus remains infective in the insect beyond the time necessary to digest a blood meal. Although one of the specimens of *v. variipennis* from New York State was collected biting man, the limited information available suggests that subspecies of *variipennis* tend to feed on mammals larger than man. (Whitehead, 1934; Wirth & Jones, 1957). Under laboratory conditions it readily engorges on cattle, sheep, rabbits and mice, preferring cattle, sheep and man in a descending sequence (Jones, 1959). Under laboratory conditions *variipennis* will engorge on chickens (Jones, 1959; Turner *et al.*, 1963).

Culicoides venustus Hoffman

Figures 62, 100, 137, 174, 214, 242, 243, 266, 268, 290

Culicoides venustus Hoffman: Thomsen, 1937: 70, figures 93, 123 (pupa); Foote & Pratt, 1954: 35-36 figures 10, 50, 84, 93 (♂, ♀). Jones, 1962a: 733, figures 7-10 (pupa).

FEMALE. Eyes contiguous; without superior transverse suture. Proboscis long, P/H ratio 0.87(0.85-0.92). Mandible with 14.0 (13-16) well developed teeth. Flagellomere length ratios 17/13/14/14/14/14/13/15/-/19/21/23/26/35, AR=1.05(0.96-1.15); sensillar pattern 3,(7),11-15. Third segment of maxillary palp slightly swollen, L/W ratio 3.04(2.50-3.47), sensory pit very shallow with pale pitted areas.

Wing length 1.47(1.37-1.55)mm., with second radial cell entirely in pale spot as shown in figure 62; macrotrichia sparse and largely confined to wing apex. Legs with distinct pale bands on basal tenth of hind tibia and at tip of femur and base of tibia on the first two pairs of legs; "knees" pale; with 5 hind tibial spines, the second longest.

Two subequal, heavily pigmented, round spermathecae with a maximum width of 46(44-47) and 42(39-45) microns respectively; neck short to moderately long, broad, tapered.

COMMENT. The wing pattern of *venustus* is unique for New York

State species. The maxillary palp is densely covered with spines giving it an unusually bristly appearance.

Venustus closely resembles the Caribbean species *insignis* which occurs as far north as Florida. The two can readily be distinguished by differences in the r-m cross-vein of the wing which in *insignis* is darkened and in *venustus* is entirely pale (see Wirth & Blanton, 1959).

MALE TERMINALIA. Ninth tergum strongly tapered posteriorly; apicolateral processes very short and slender, they would not touch if directed medially; median notch distinct narrow V-shaped; ninth sternum with a narrow V-shaped posterior emargination, membrane not spiculate. Basistyle with ventral root indicated only by a slight pointed protuberance; dorsal root moderately long, strongly tapered.

Paramere with distal third very slender, ending with a fine apical tip with microscopic hairs, curving inwardly and ventrally in a loop; basal half of paramere much swollen elongate subtriangular. Aedeagus with an elongate, slender, parallel sided, median posterior process, slightly swollen and rounded at apex, lateral arms nearly straight, joined near base by a transverse sclerotized bar; the area bounded by the lateral arms and transverse bar joined by sclerotized membrane.

COMMENT. The aedeagus resembles that of *chiopterus* but the other details of the male terminalia of these two species are quite different. The terminalia is similar to that of *insignis* but the two species can be separated by wing markings (see female).

PUPA. Respiratory horn concolorous with rest of pelt, darkened apically, with 12.4(11-13) apical and no lateral spiracular openings; horn with spines present in small numbers on most of basal two-thirds, widest near apex, L/W ratio 7.4(6.4-8.4). Operculum with short stout spines confined almost entirely to lateral margins, with a unique well developed, elongate nodule on midline near posterior end (figure 242); *am* setae short and stout, about one-quarter as long as maximum width of operculum. The *d* tubercles 1 to 3 in line, about equidistant, with seta 1 moderately long and stout, 2 longer and more slender; thoracic surface between and adjacent to tubercles strongly papillate.

Abdomen with fine spines confined mostly to anterior margins of segments. The *lpm* tubercles elongate, rather variable, usually weakly bifid, sometimes ridged or with a single point and a subapical seta; last segment with a patch of spines on disc; caudal apicolateral processes with spines, tips darkened on apical third, directed posteriorly at an angle of 20 to 45 degrees to the longitudinal axis of the body. COMMENT. The respiratory horn of *venustus* is unique in having

no lateral spiracular openings; and in having the tracheal rings extending anteriorly about two-thirds horn length; it resembles the *obsoletus* group in having *d* seta 2 longer than seta 1, and in having two long, nearly equal *ad* setae.

FOURTH INSTAR LARVA. Length of frontoclypeus 254(235-279) microns. Comb with 10.8(9-12, $n=4$) teeth on each half; total comb width 43(39-45) microns; head capsule brown, slightly darker posteriorly.

Thorax with a spotty, faint, purplish mottling, most extensive on prothorax, often very faint or inapparent.

COMMENT. *Venustus* larvae have a unique dark brown head capsule.

DISTRIBUTION. *Venustus* is generally distributed in the states east of the Mississippi River, from Florida to Vermont. It has been recorded from Ala., Conn., Del., Fla., Ga., Md., Mass., Mich., Miss. N. Y., N. C., Pa., Vt., Va., Wis.

New York State Records

Albany County, Altamont, Quay Rd., stream edge, July 1, 1963—6, reared larva July 1, pupated July 3, ♂ emerged July 7, coll. HAJ.

Chautauqua County, Sinclairville, muddy brook, May 31, 1963, 1 ♂ and 3 ♀♀; Ivory, grassy puddle, May 31, 1963, reared 3 ♂♂ and 3 ♀♀, coll. WWW.

Cattaraugus County, Allegany State Park, France Brook, June 3, 1963, 8 ♂♂ and 9 ♀♀, coll. WWW.

Lewis County, Port Leyden, swamp, July 4, 1959—3, reared pupa July 9, ♂ emerged July 11, Berlese funnel sample, coll. M. McFadden; Watson, Pine grove, June 22, 1963, 2 ♂♂ in LT, coll. WWW.

Rensselaer County, Nassau (Foote & Pratt, 1954).

St. Lawrence County, 4 mi. nw of Canton, Rte. 68, wet meadow, cow hoofprints, July 15, 1963—3, reared larva, pupated July 19, ♂ emerged July 24, coll. HAJ.

Schuyler County, Mecklenburg, Creek margin, June 17, 1963, reared 1 ♂ and 1 ♀, coll. WWW.

Tompkins County, Ithaca, Ellis Hollow, June 19, 1963, 3 ♀♀ in LT; June 1963, 1 ♂ in LT, coll. C. O. Berg.

Washington County, Cambridge, Fish hatchery area, wet meadow, cow hoofprints, July 11, 1963—11, reared larva July 11, pupated July 15, ♀ emerged July 19; same location, June 21-25, 1963, 1 ♂ and 2 ♀♀ in LT, coll. HAJ.

BIOLOGY. *Seasonal distribution.* Snow *et al.* (1957) reported that *venustus* was present from early spring until fall, with a peak in mid-June in the Tennessee Valley area. Murray (1957), collecting in Virginia for a somewhat shorter period, found *venustus* adults from June into September with a peak in late June to mid-July. Williams (1955a) collected adults in October and November, but not in August and September in Georgia. Our rather limited data would seem to confirm findings that adults are present all summer. We have never collected this species in large numbers in light traps, but have collected several larvae in a single sample of mud and grass from a cow's hoofprint.

Breeding sites. In common with other workers we have collected larvae and/or pupae along stream margins (Snow *et al.*, 1957; Jones, 1961b). One pupa was collected from a swamp at water level. The substrate has usually consisted of mud, or mud with grass roots often where depressed by cattle hoofs; one of our reared larvae was found in sphagnum moss bordering a stream.

Feeding habits. Unknown. *Venustus* has a long proboscis, well developed mandibular teeth, and strong tormae. It is very probably a blood feeder but apparently is not attracted to man. Snow & Pickard (1954) note that, although it was present in light traps, it was not collected feeding on man in Tennessee. The relatively small number of sensilla suggests that it is mammalophilic.

Culicoides villosipennis Root & Hoffman

Figures 63, 101, 138, 175, 215

Culicoides villosipennis Root & Hoffman: Fox, 1942: 416, figures 7, 10 (pupa); Foote & Pratt, 1954: 36, figures 28, 54, 71, 116 (♂, ♀); Jones & Wirth, 1958: 84-86 (♀).

FEMALE. Eyes narrowly to moderately separated. Proboscis long, P/H ratio 0.81(0.77-0.87). Mandible with 13.4(13-14, n=10) well developed teeth. Flagellomere length ratios 15/11/13/13/14/13/14/14/-/31/29/32/32/40, AR=1.46(1.40-1.52); sensillar pattern 3, 5, 7, 9, 11-15. Third segment of maxillary palp moderately to greatly swollen, L/W ratio 2.38(1.67-2.80), sensory pit deep, with large opening.

Wing length 1.49(1.35-1.61)mm., with distinct pale spots as indicated in figure 63, resembling *guttipennis*, but differs in having a much smaller pale spot over r-m cross-vein; macrotrichia abundant over entire wing. Legs with distinct pale bands; five hind tibial spines with the second longest.

Two subequal, subelliptical, slightly asymmetrical, heavily pigmented spermathecae with a maximum width of 42(39-45) and 39 (33-44) microns respectively, neck very short, tapering.

COMMENT. This species closely resembles *guttipennis*, differing mainly in having fewer mandibular teeth, a slightly shorter proboscis, a more swollen third segment of the maxillary palp, and different wing markings.

MALE TERMINALIA. Ninth tergum with stout apicolateral processes which would touch if directed medially; median notch narrow V-shaped; ninth sternum with a broad shallow to deep concave posterior emargination; membrane not spiculate. Basistyle with ventral root moderately long, slightly tapered; dorsal root similar in appearance, slightly longer.

Paramere tapering gradually to a fine bare point, curved outwardly ventrally and posteriorly forming a semicircle; paramere becoming gradually more swollen posteriorly, where it is narrowly joined to an antero-posteriorly directed accessory process. Aedeagus with a long, slender, median posterior process, which terminates in a rounded tip with two large secondary pointed tips originating near distal end, one on each side of the median tip; lateral arms with flange at base.

COMMENT. This is the only species occurring in New York State in which the median posterior process of the aedeagus terminates in three separate tips.

PUPA. Agreeing with the description of *guttipennis*, except; respiratory horn longer and more slender, widest near base, L/W ratio 5.3-6.8(n=2) with 7 apical and 3 lateral (n=2) spiracular openings. Abdomen including dorsum of last segment largely covered with fine spines which are not confluent as in *guttipennis*. Very closely resembles *arboricola*. The only clearcut difference noted between the two pupal skins (of reared adults) of each species available for study was in the number of apical spiracular openings on the respiratory horn.

FOURTH INSTAR LARVA. Only one cast larval skin of a reared *villosipennis* was available for examination. Frontoclypeus 218 microns long. The last segment of the abdomen with stout long setae as in *guttipennis*. The larval comb could not be located on the slide; with the characters available, we cannot distinguish this larva from *guttipennis*.

DISTRIBUTION. *Villosipennis* is most common in the southeastern states, but has been collected as far north as Maine. It has been recorded from Ala., Fla., Ga., La., Me., Md., Mass., N. Y., Okla., Tenn., Tex., and Va.

New York State Records (first records from State)

Albany County, E. Berne, Jamnback's woods, sugar maple treehole, July 18, 1963, reared larva, pupated July 19, ♀ emerged July 26; same collection, reared pupa, ♂ emerged July 22, coll. HAJ.

Essex County, Newcomb, Hamilton-Essex Line beside Rte. 28N, June 26, 1959, 1 ♀ in LT; same location July 27, 1960, 1 ♀ in LT; same location, August 30, 1959, 1 ♂ in LT, coll. HAJ.

Hamilton County, Blue Mountain L., Sphagnum Bog, July 19, 1960, 1 ♂ and 2 ♀ ♀ in LT; same location, August 30, 1960, 1 ♂ in LT; Stanton place, June 23, 1959, 1 ♀ in LT; Eagle Nest, July 31, 1962, 1 ♂ in LT beside chicken house; same location July 31, 1962, 1 ♀ in LT; Salmon River, July 19, 1960, 1 ♀ in LT, coll. HAJ.

Suffolk County, Mastic Beach, July 2-5, 1953, 1 ♀ in LT, coll. HAJ.

BIOLOGY. *Seasonal distribution.* *Villosipennis* adults have been collected from early spring to late fall (Foote & Pratt, 1954). Murray (1957) collected it in relatively large numbers (183 adults) between the last week in June and mid-July, in Virginia. In New York State, relatively few adults have been collected, most of these during the last half of July.

Breeding sites. Many collection and rearing records indicate that *villosipennis* breeding is confined to moist or wet treehole cavities.

Feeding habits. Unknown. The long proboscis, well developed mandibular dentition, and strong tormae suggest that it is haematophagus. The large number of flagellar sensilla suggest that it may be primarily ornithophilic. There are no records of its biting man.

Culicoides wisconsinensis Jones

Figures 64, 102, 139, 176, 183, 216, 244, 267, 291

Culicoides wisconsinensis Jones, 1956: 32-33, figures 12-16 (♂. ♀).

FEMALE. Eyes widely separated. Proboscis short to intermediate in length, P/H ratio 0.63(0.58-0.67, n=3). Mandible with 7.3(7-8, n=6) moderately developed teeth. Flagellomere length ratios 14/9/9/9/9/9/10/-/14/15/15/17/21, AR=1.10(1.00-1.19, n=4); sensillar pattern 3, (4), (5), (7), (8), 11, 13, 14. Third segment of maxillary palps greatly swollen, L/W ratio 2.10(1.88-2.50, n=4) with large, shallow sensory pit.

Wing length 1.20(1.11-1.29, n=3)mm., with indistinct to distinct pale spots present in addition to those just beyond the second radial cell and over r-m cross-vein. These most distinct in cell M_{3+4} and anal cell, coarse macrotrichia abundant over most of wing. Legs with very indistinct pale bands; 4 hind tibial spines with the second usually longest.

One heavily pigmented, elliptical spermatheca 70(63-75, n=3) microns maximum width, neck long, parallel sided.

COMMENT. The description of *wisconsinensis* closely parallels that of *bermudensis* but *wisconsinensis* is a much darker brown species with a smaller spermatheca and hairier wing.

MALE TERMINALIA. Closely resembling *hollensis* except the dististyle is less swollen at the base (cf. figures 11 and 26); the apicolateral processes are slightly longer and would almost touch if directed medially. The paramere of *wisconsinensis* is joined to the accessory processes at about a right angle rather than at about a 45 degree angle as is the case with *crepuscularis* and *hollensis*.

The wing resembles that of *hollensis* in having a rather faint or inapparent pattern.

PUPA. Respiratory horn brown to dark brown, slightly darker apically, with 11.2(10-13) apical and 2.8(2-3) lateral spiracular openings; narrowed near middle, with numerous well developed scale-like spines on median two-thirds, some forming transverse wrinkles, widest near base, L/W ratio 5.7(5.2-6.2). Operculum covered densely with short stout spines; *am* setae stout, long, more than four-tenths as long as maximum width of operculum. The *d* tubercles in line, setae 1 and 2 closer than 2 and 3, setae 1 and 2 moderately long, not overlapping; thoracic surface between and adjacent to tubercles rough, covered with very numerous papillae.

Abdomen with fine spines confined mostly to anterior margins of segments, sparse elsewhere. The *lpm* tubercles rounded or weakly ridged; last segment without patch of spines on disc; caudal apico-lateral processes with small spines, distal half dark brown, directed posteriorly at an angle of 30 degrees or less to the longitudinal axis of the body.

COMMENT. This pupa is very similar to *crepuscularis* but is more heavily pigmented, the horn has more apical spiracular openings, and the last segment lacks a patch of spines on the disc.

FOURTH INSTAR LARVA. The larvae of *wisconsinensis* could not be distinguished from *crepuscularis* by the head length, comb structure, or thoracic pigmentation. Frontoclypeus 173(143-187, $n=4$) microns long. Comb with 8-9($n=2$) unequal teeth on each half; total comb width 24-29($n=2$) microns; head capsule pale yellow.

DISTRIBUTION. N. Y., Wis.

New York State Records (first records from State)

Onondaga County, Syracuse, marsh near Fort Ste. Marie de Gannentaha, May 16, 1963—3,4, reared larva, pupated May 18, ♂ emerged May 23; same collection, reared 4 pupae, 1 ♂ emerged May 19, 1 ♀ May 20, 2 ♂ ♂ May 23; same collection, 1 ♀ in sample; marsh beside MacArthur Stadium, May 16, 1963—5,6, reared larva, pupated May 20, ♂ emerged May ?; same collection, reared 2 pupae, 1 ♂ and 1 ♀ emerged May 20, coll. HAJ.

Seneca County, Montezuma Swamp, lagoon margin, June 1, 1963—1, reared larva, pupated June 15, ♂ emerged June 22; same collection, reared larva, pupated June 17, ♀ emerged June 21, same collection, reared 2 larvae, pupated June 16-18, 1 ♂ emerged June 20 and 1 ♀ June 21.

BIOLOGY. *Seasonal distribution.* Jones (1956) reared adults in May and October and collected others in a light trap in June. We have reared adults in May and June but did not collect later in the season at these sites.

Breeding sites. In Wisconsin, Jones (1956) reared *wisconsinensis* from peat muck at the margin of Lake Mendota. In New York State, it was reared from brackish water marshes in a saline area near Syracuse, and in Montezuma Swamp from the margins of a fresh water lagoon. In both cases, the substrate was a thin layer of soft mud over a firmer sod.

Feeding habits. Unknown. The proboscis is short and the mandibular dentition not strongly developed, however the tormae are strongly sclerotized. *Wisconsinensis* is probably not *haematophagus*.

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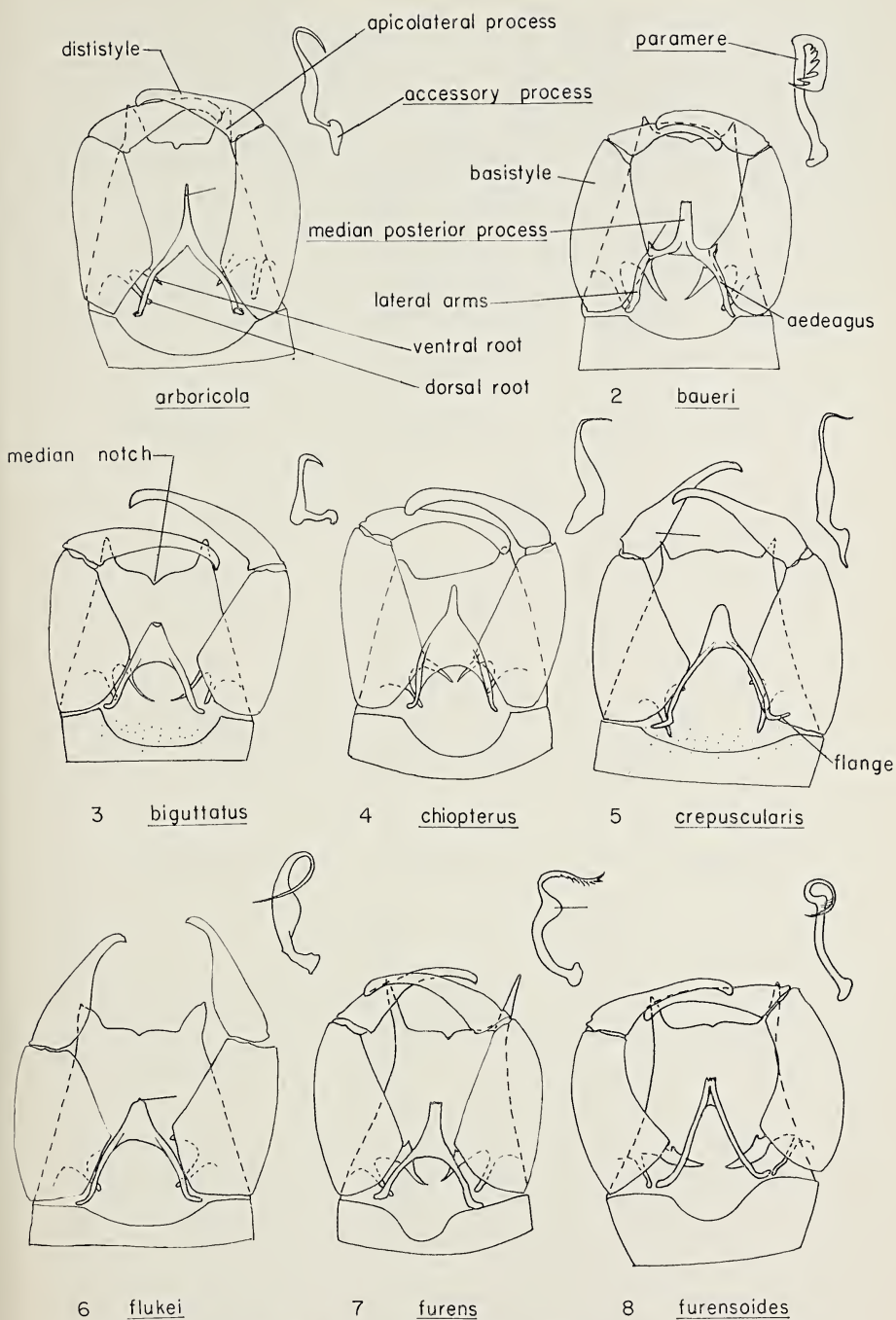


PLATE I. Figures 1-8, male terminalia.

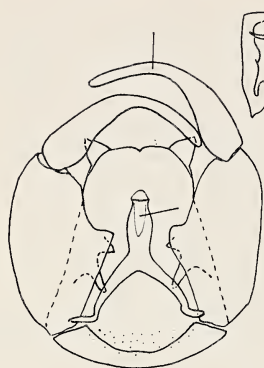
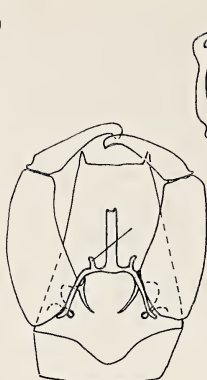
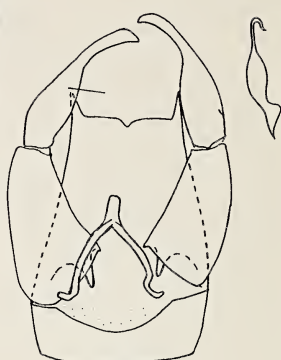
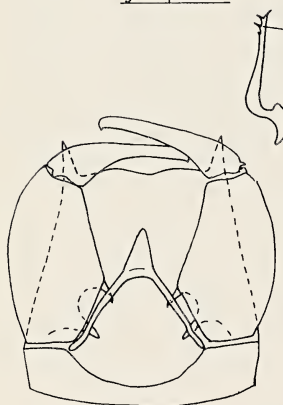
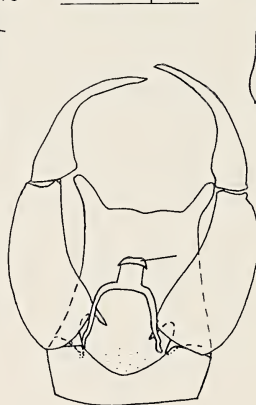
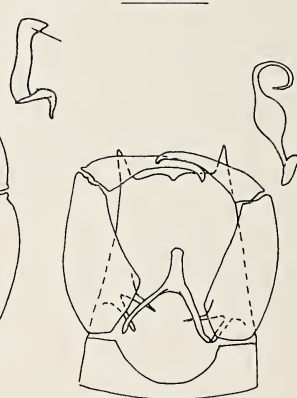
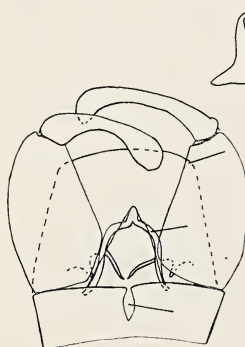
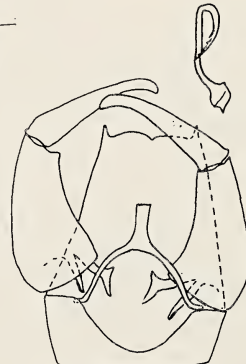
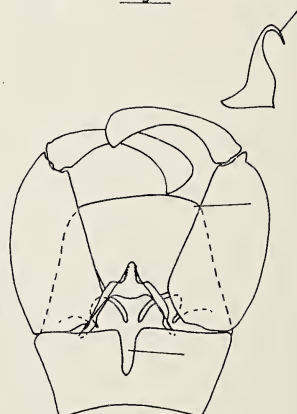
9 guttipennis10 haematopotus11 hollensis12 loisae13 melleus14 niger15 obsoletus16 piliferus17 sanguisuga

PLATE II. Figures 9-17, male terminalia.

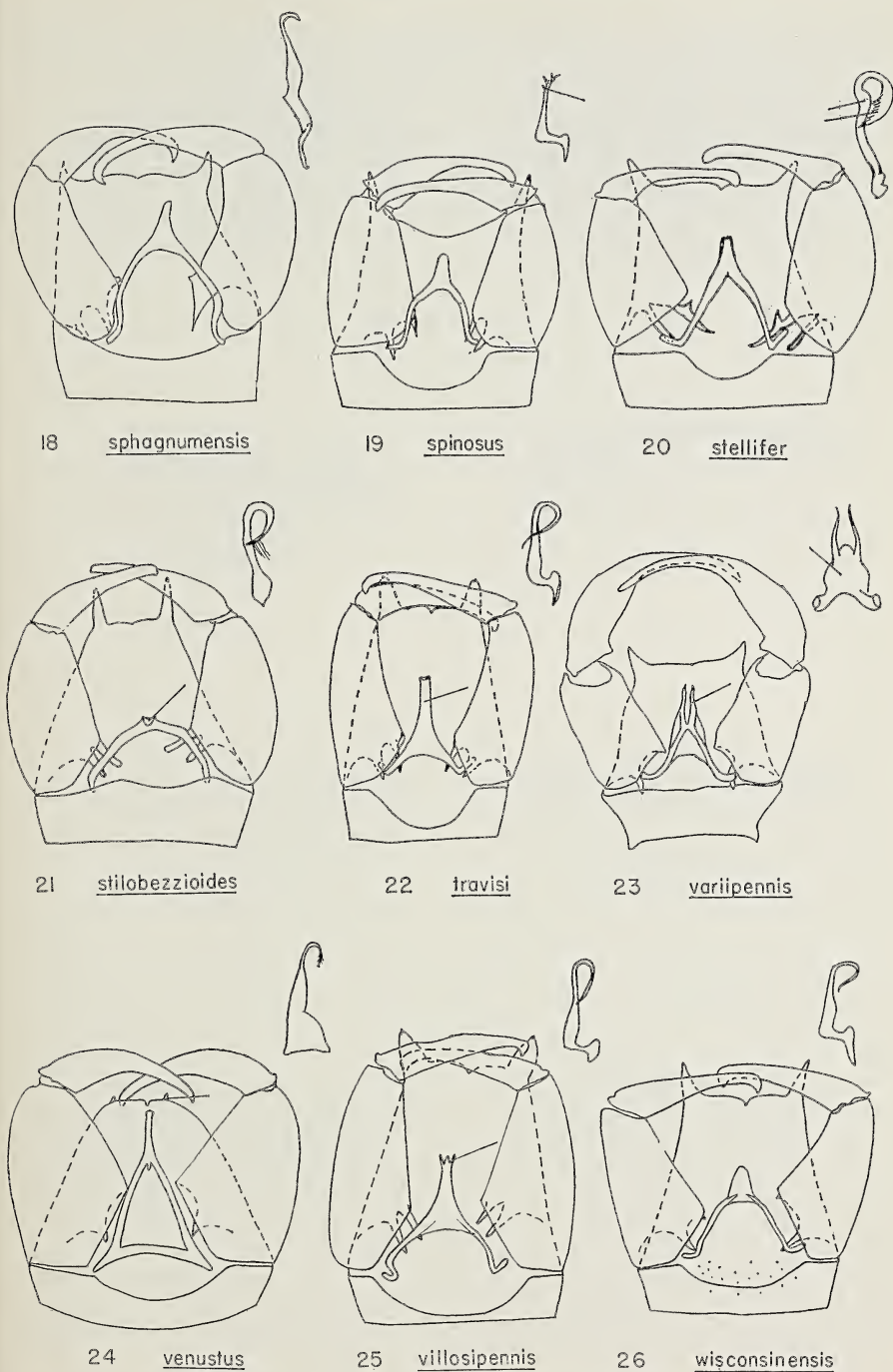


PLATE III. Figures 18-26, male terminalia (Figure 18 redrawn from Williams, 1955c; Figure 23 redrawn from Wirth & Jones, 1957).

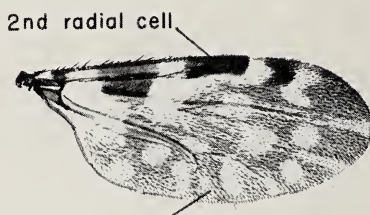
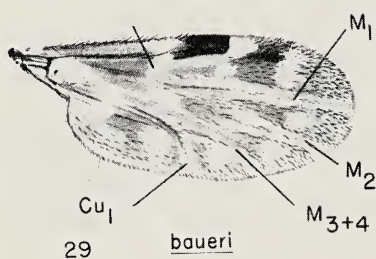
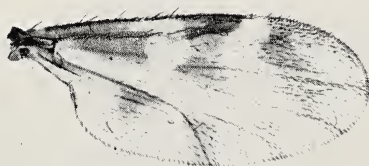
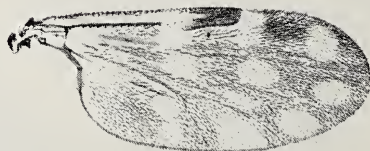
27 alexanderi28 arboricola29 baueri30 bermudensis31 bickleyi32 biguttatus33 chiopterus34 crepuscularis

PLATE IV. Figures 27-34, female wings.

U.S. Army photographs

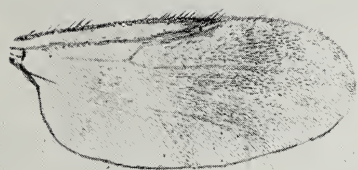
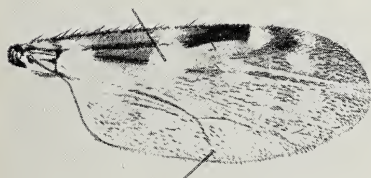
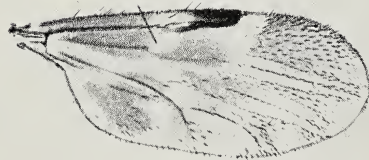
35 denticulatus36 dickei37 downesi38 flukei39 furens40 furensoides41 guttipennis42 haematopotus

PLATE V. Figures 35-42, female wings.

All except Figure 38 U.S. Army photographs

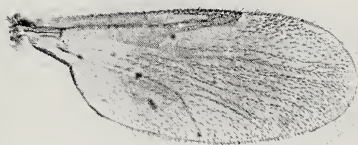
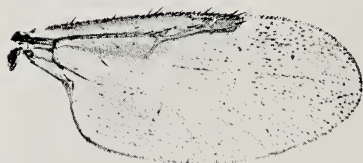
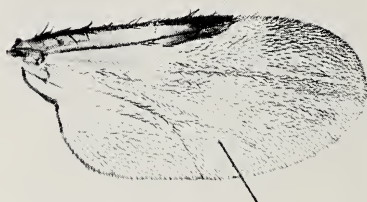
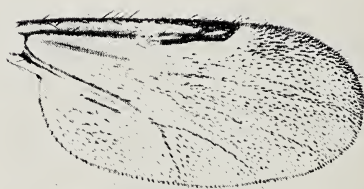
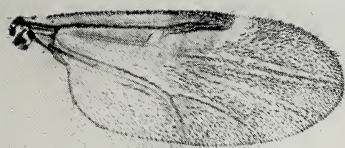
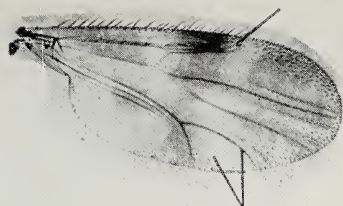
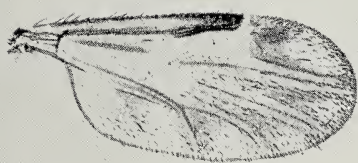
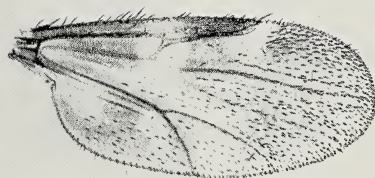
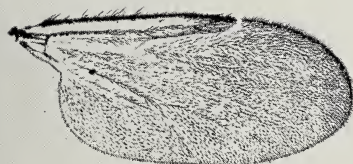
43 hollensis44 jamnbacki45 loisae46 melleus47 nanus48 niger49 obsoletus50 piliferus

PLATE VI. Figures 43-50, female wings.

U.S. Army photographs

51 pseudopiliferus52 sanguisuga53 scanloni54 sphagnumensis55 spinosus56 stelliter57 stilobezzioides58 testudinalis

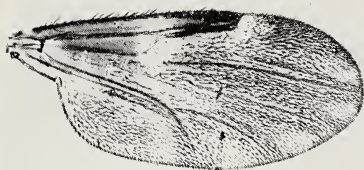
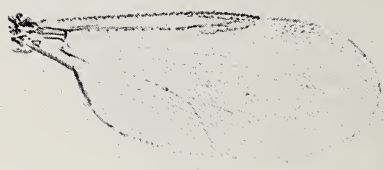
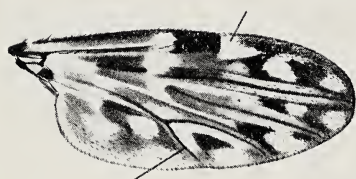
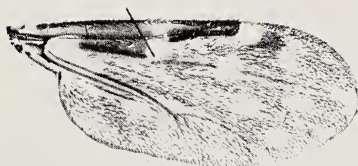
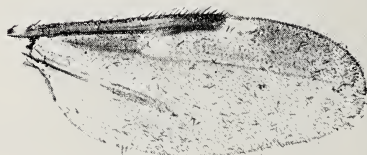
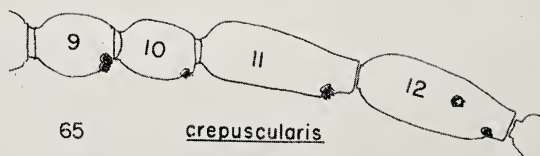
59 travisi60 utowana61 variipennis62 venustus63 villosipennis64 wisconsinensis65 crepuscularis

PLATE VIII. Figures 59-64, female wings; Figure 65 portion of female antenna showing sensilla.

All except Figures 60 and 65 U.S. Army photographs

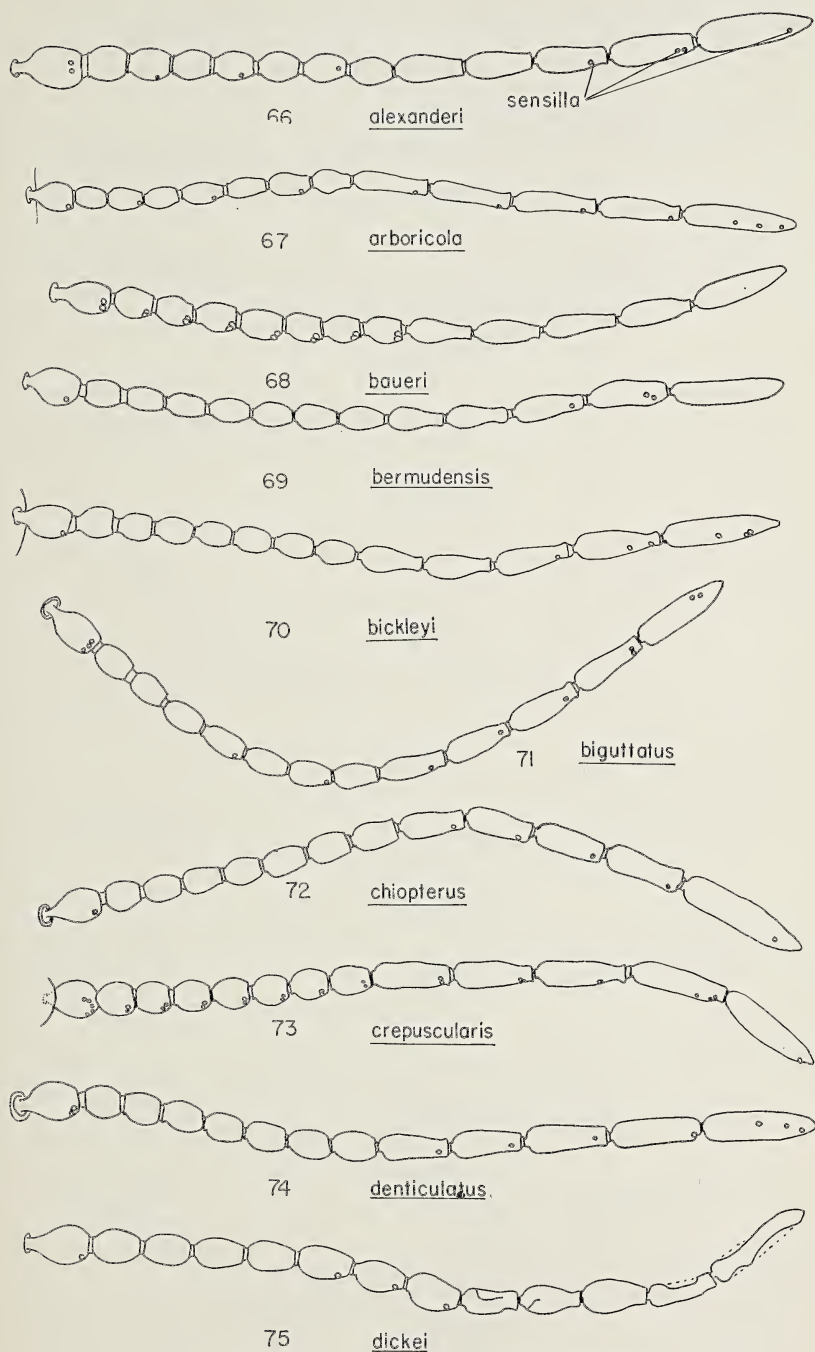


PLATE IX. Figures 66-75, female antennae.

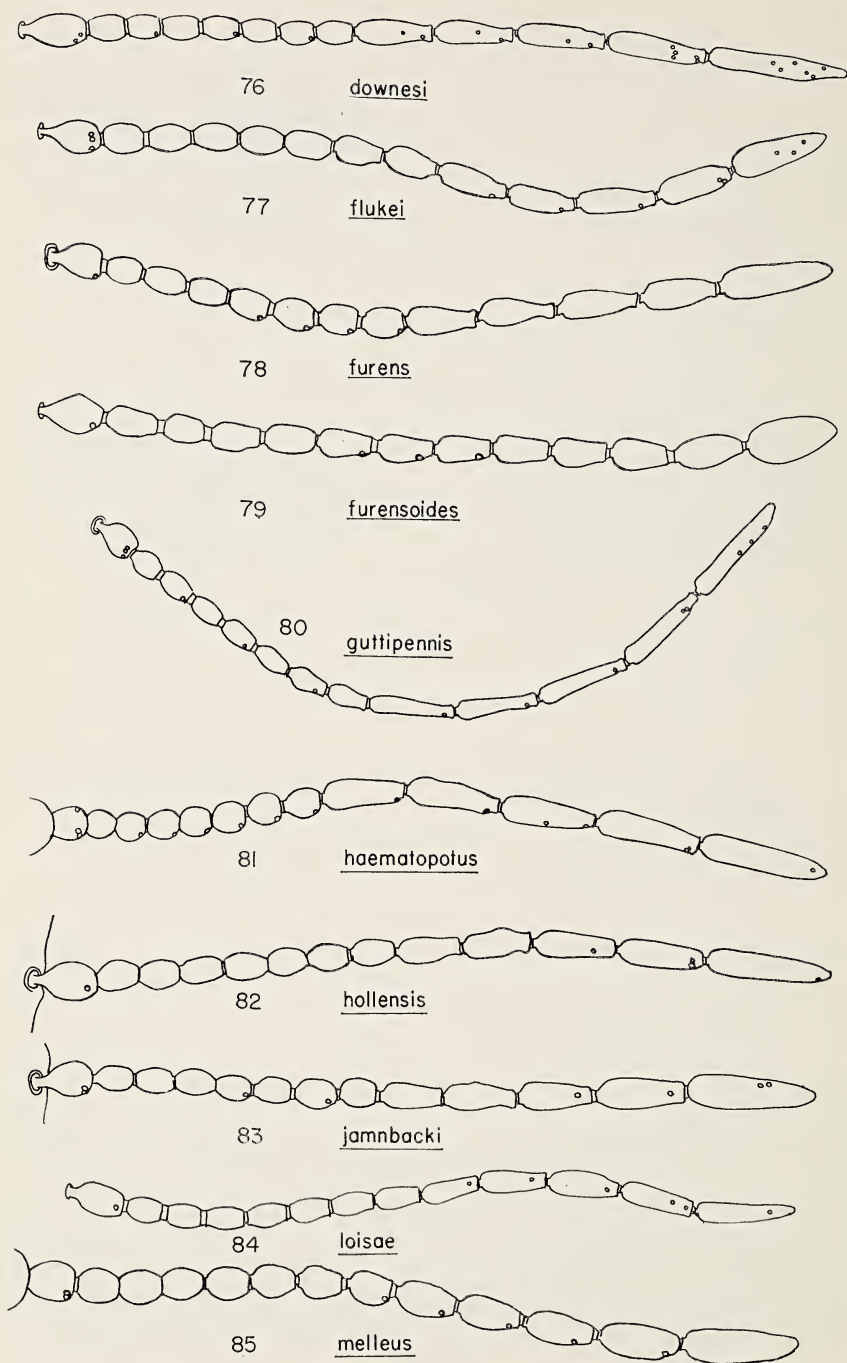


PLATE X. Figures 76-85, female antennae.

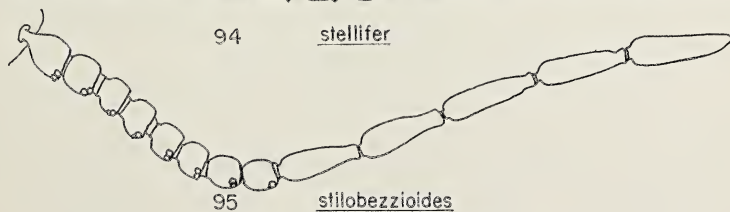
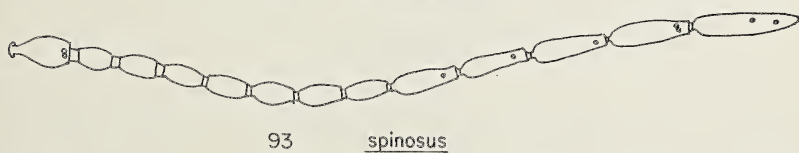
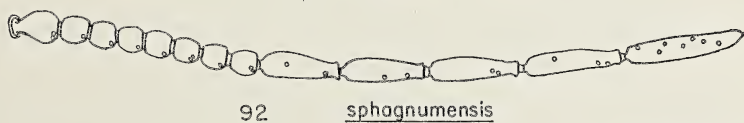
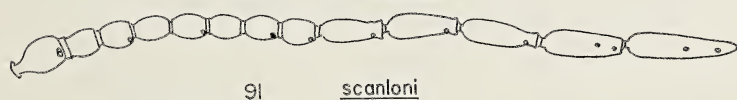
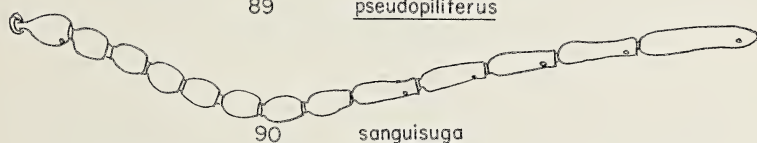
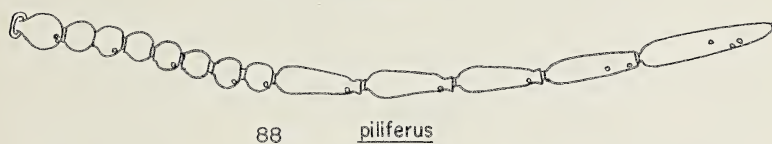
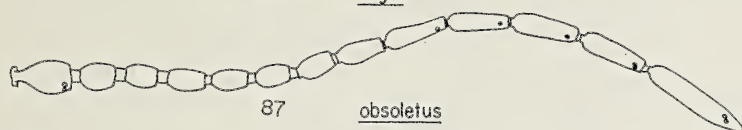
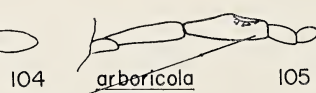
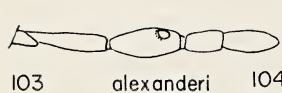
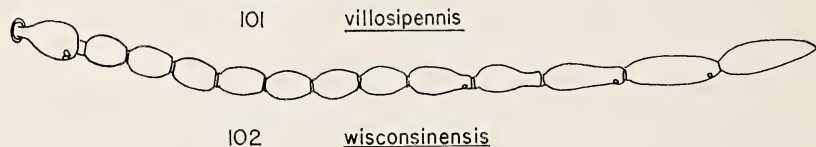
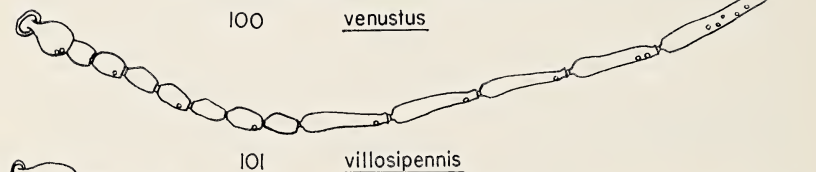
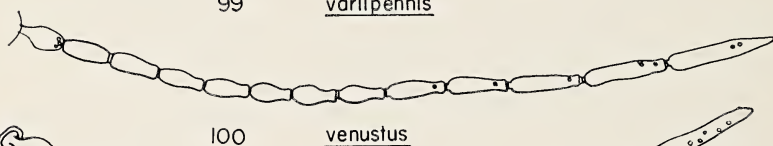
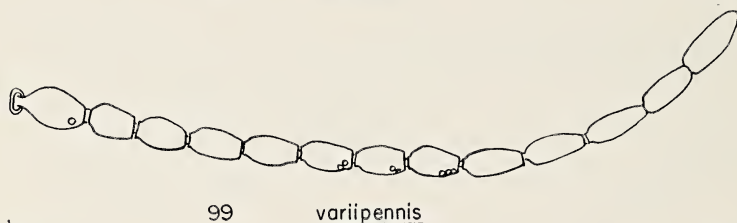
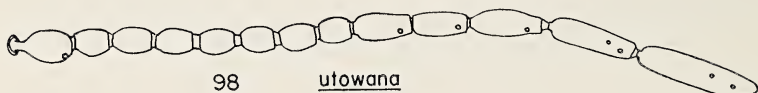
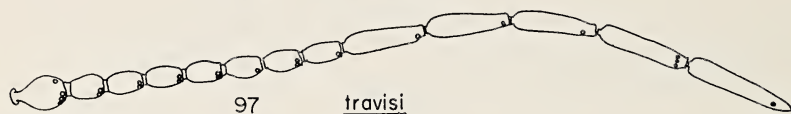
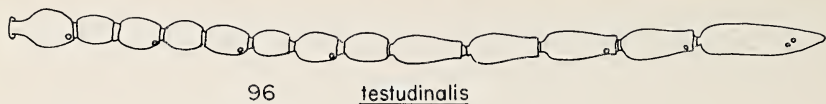
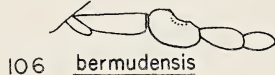


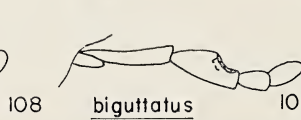
PLATE XI. Figures 96-95, female antennae.



slightly swollen



greatly swollen



moderately swollen

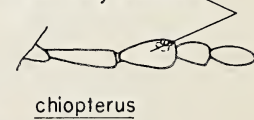


PLATE XII. Figures 96-102, female antennae; Figures 103-109, female maxillary palps.

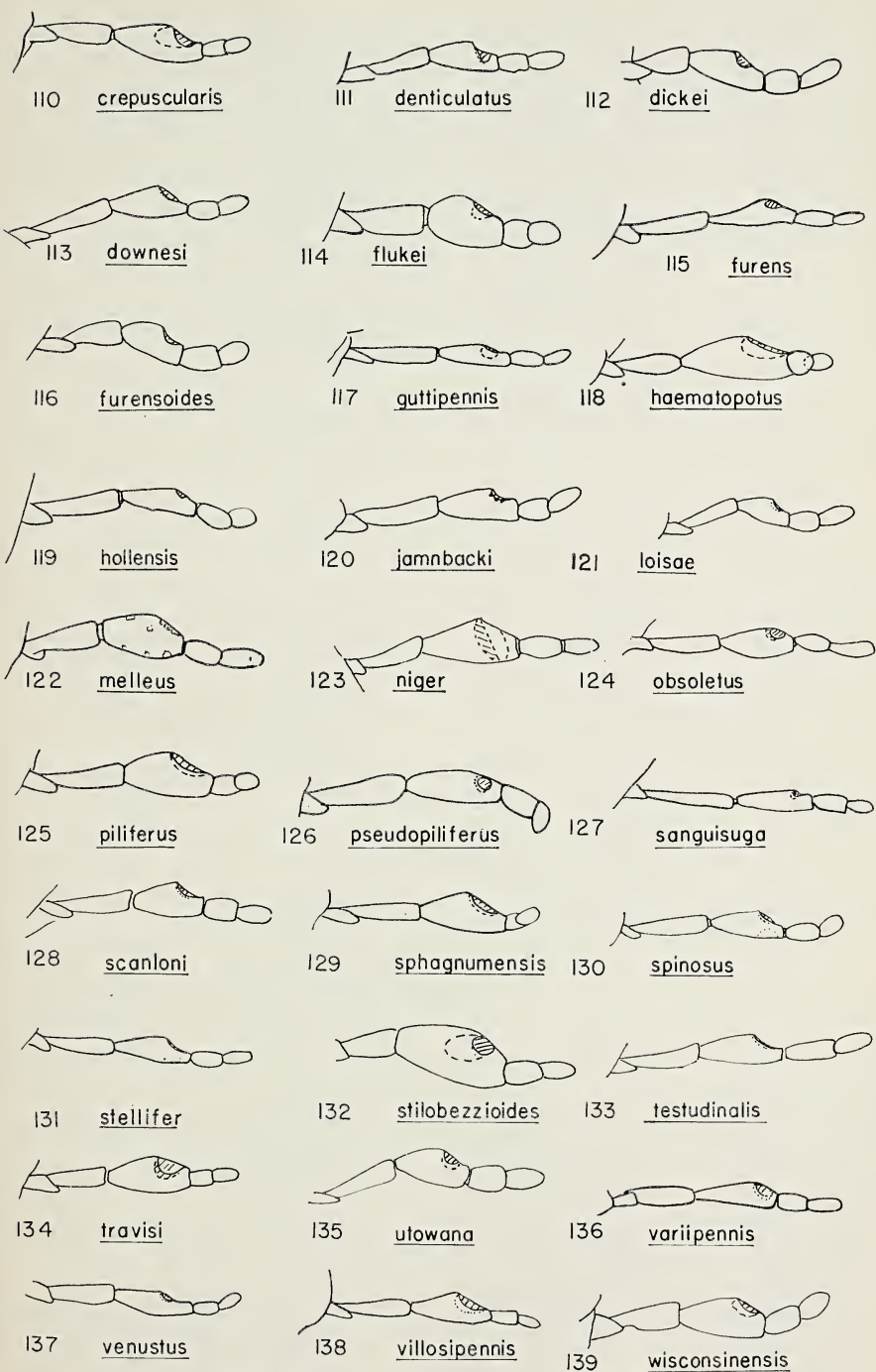


PLATE XIII. Figures 110-139, female maxillary palps.

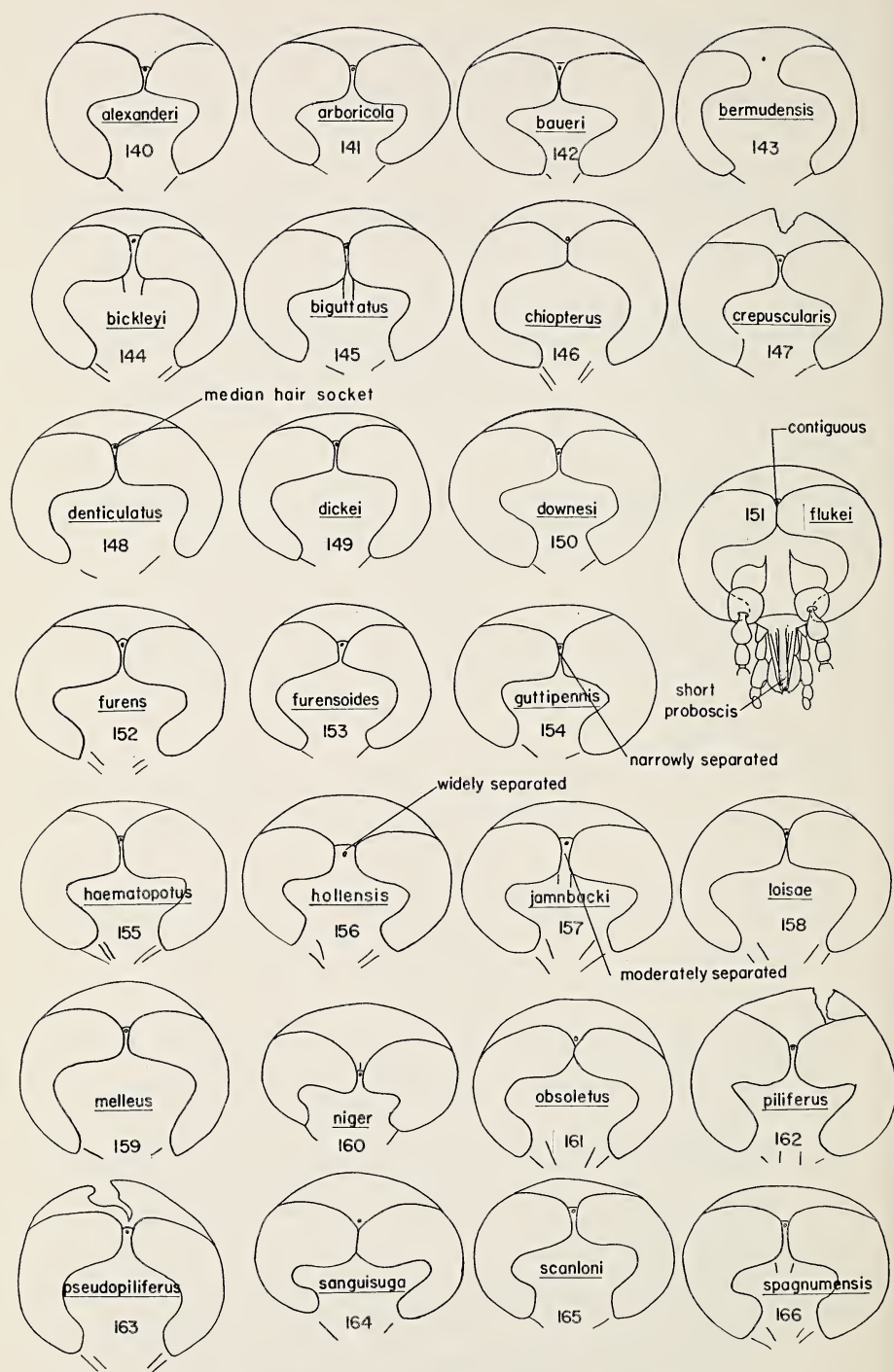


PLATE XIV. Figures 140-166, female heads.

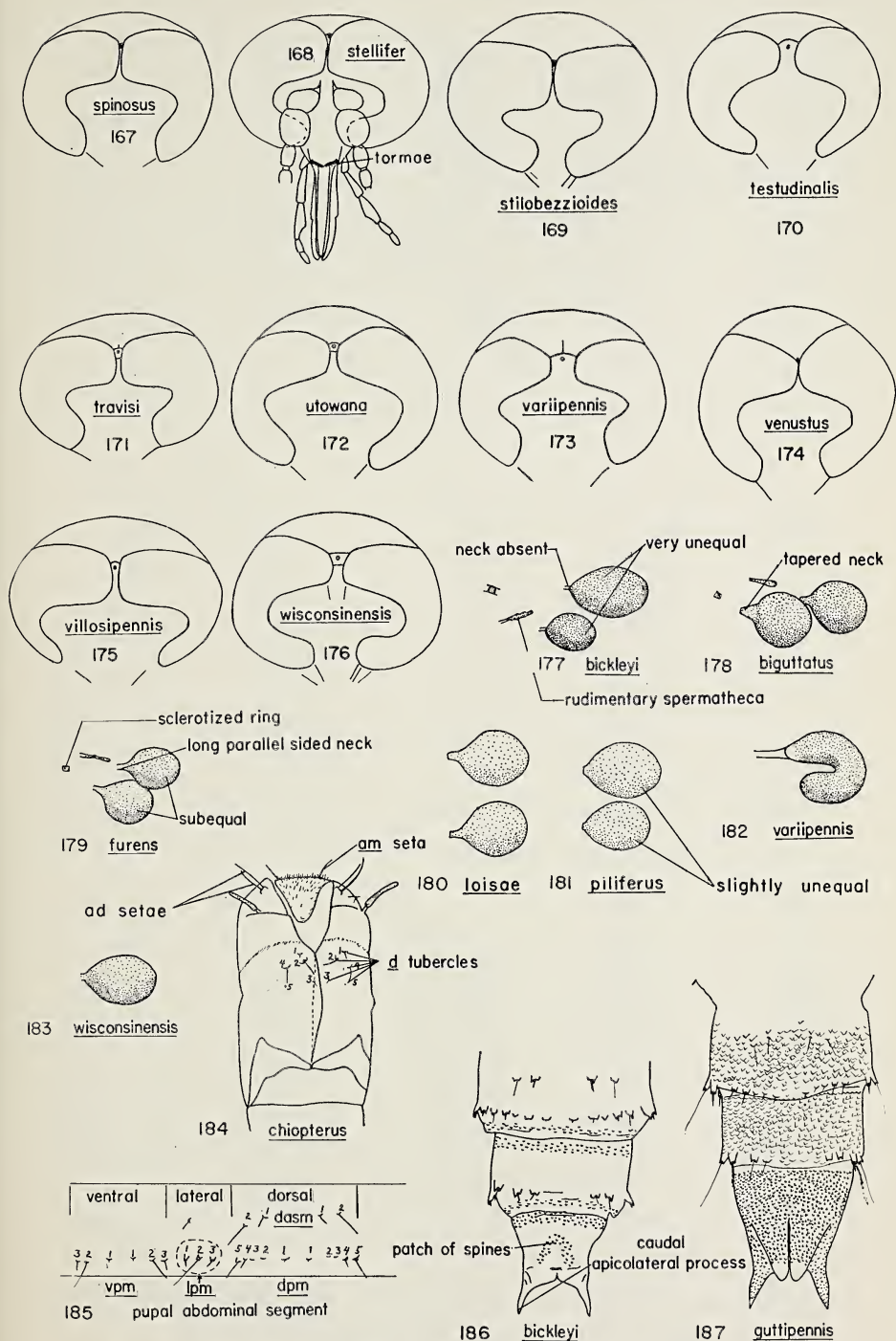


PLATE XV. Figures 167-176, female heads; Figures 177-183 female spermathecae; Figure 184 pupal thorax; Figure 185, pupal abdominal segment (redrawn from Ann. Ent. Soc. Amer. 57:731, by permission of R. H. Jones and E.S.A.);

Figures 186, 187 pupal abdomen, terminal segments.

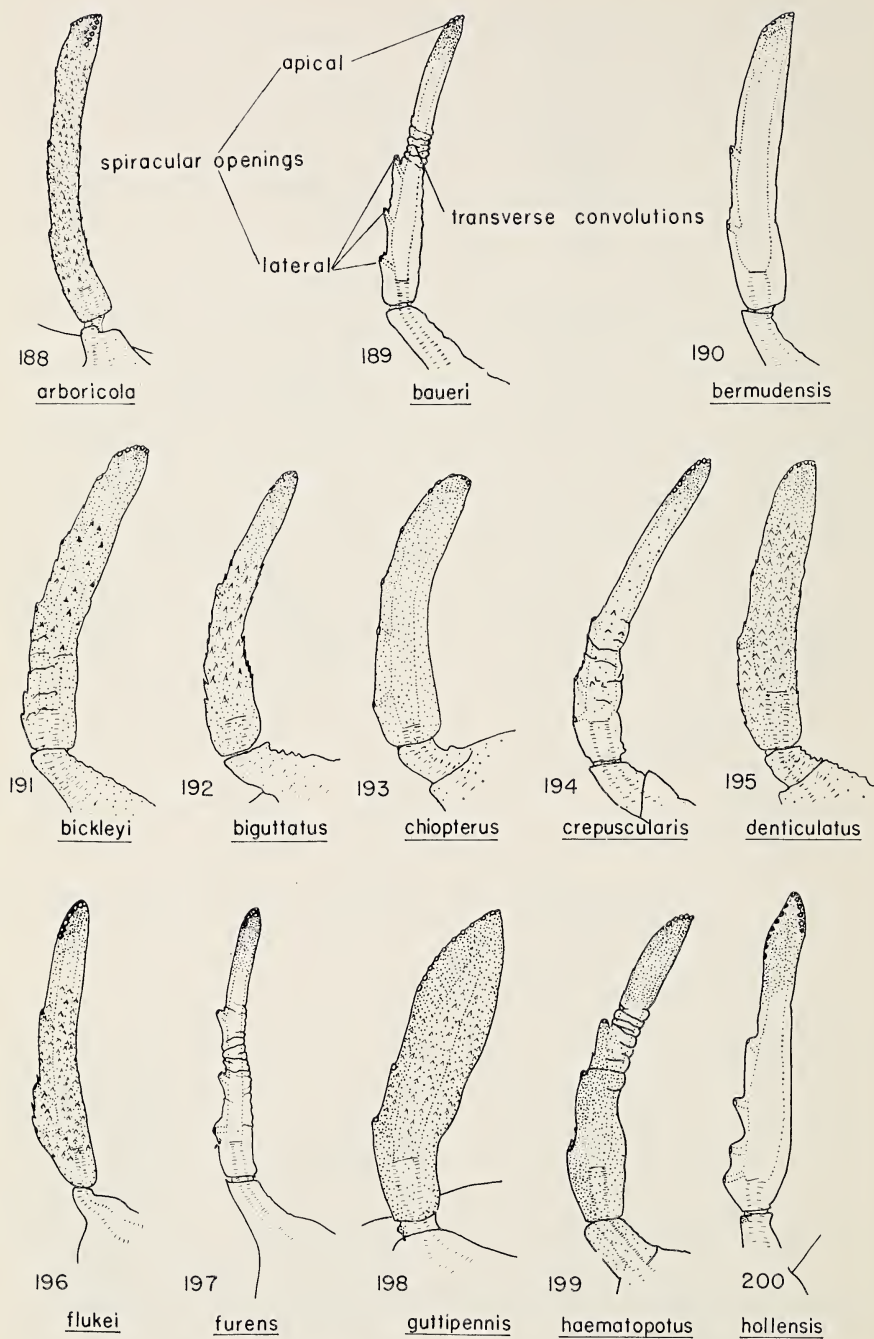


PLATE XVI. Figures 188-200, pupal respiratory horns.

201 jamnbacki202 loisae203 melleus204 niger205 obsoletus206 piliferus207 pseudopiliferus208 sanguisuga209 spinosus210 stellifer211 testudinalis212 utowana213 varlipennis214 venustus215 villosipennis

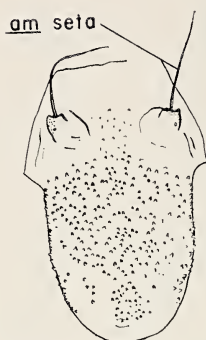
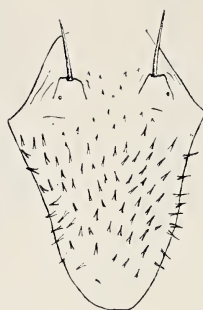
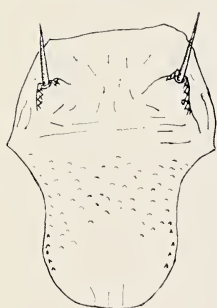
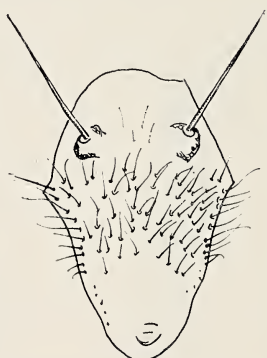
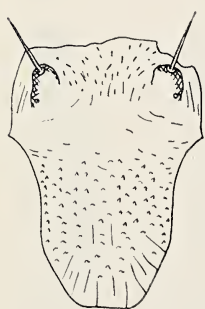
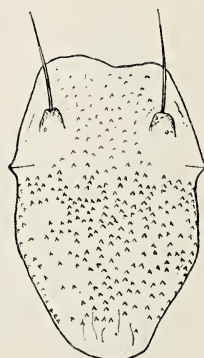
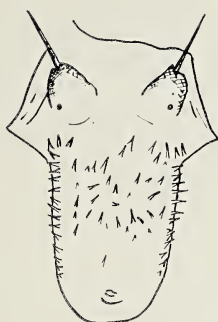
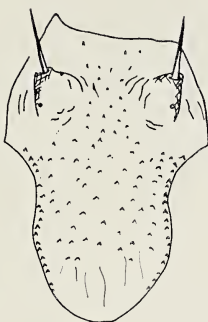
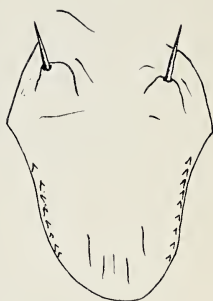
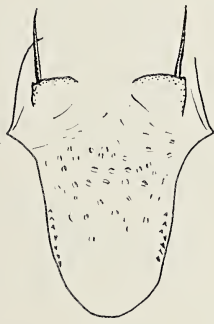
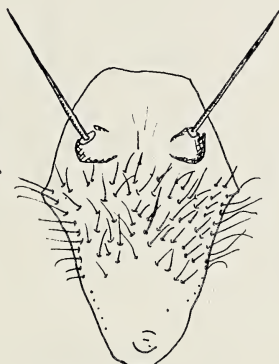
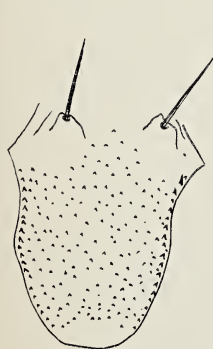
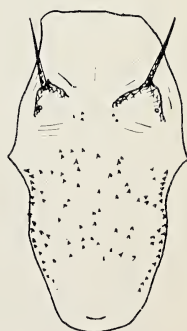
216 wisconsinensis217 arboricola218 baueri219 bermudensis220 bickleyi221 biguttatus222 chiopterus223 crepuscularis224 denticulatus225 flukei226 furens227 gutipennis

PLATE XVIII. Figure 216, pupal respiratory horn; Figures 217-227, pupal opercula.

228 haematopodus229 hollensis230 jamnbacki231 loisae232 melleus233 niger234 obsoletus235 piliferus236 pseudopiliferus237 sanguisuga238 spinosus239 stellifer

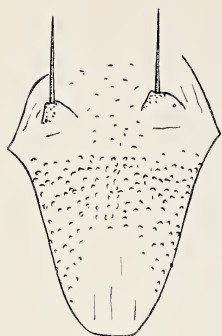
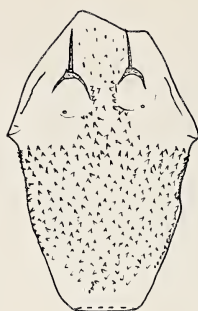
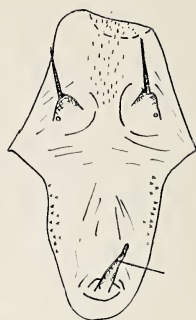
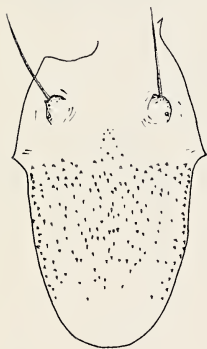
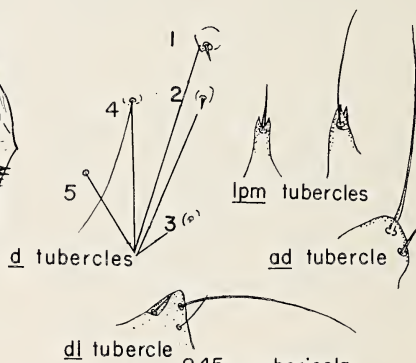
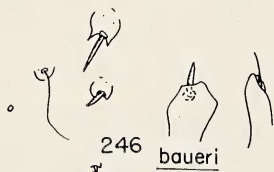
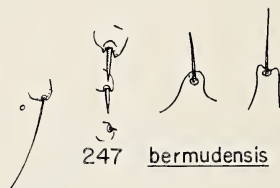
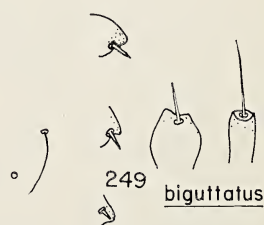
240 utowana241 variipennis242 venustus243 villosipennis244 wisconsinensis245 arboricola246 baueri247 bermudensis248 bickleyi249 biguttatus

PLATE XX. Figures 240-244, pupal opercula; 245-249 pupal tubercles and spines (Figures 246-249 *d* and *lpm* tubercles only).

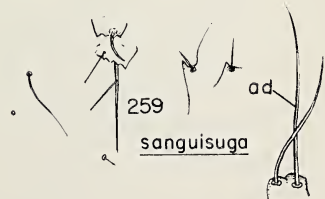
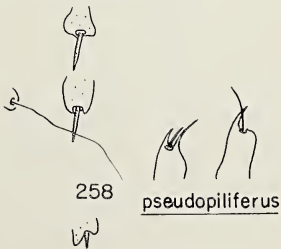
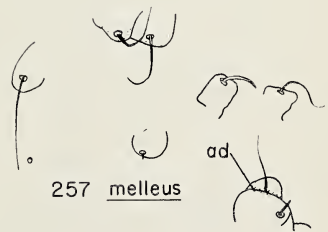
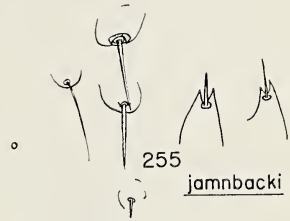
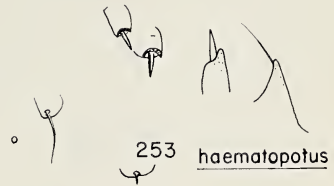
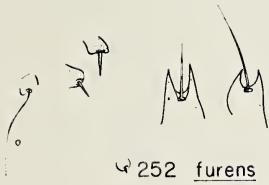
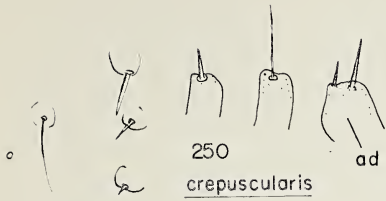


PLATE XXI. Figures 250-259, pupal tubercles and spines (*d* and *lpm* tubercles).

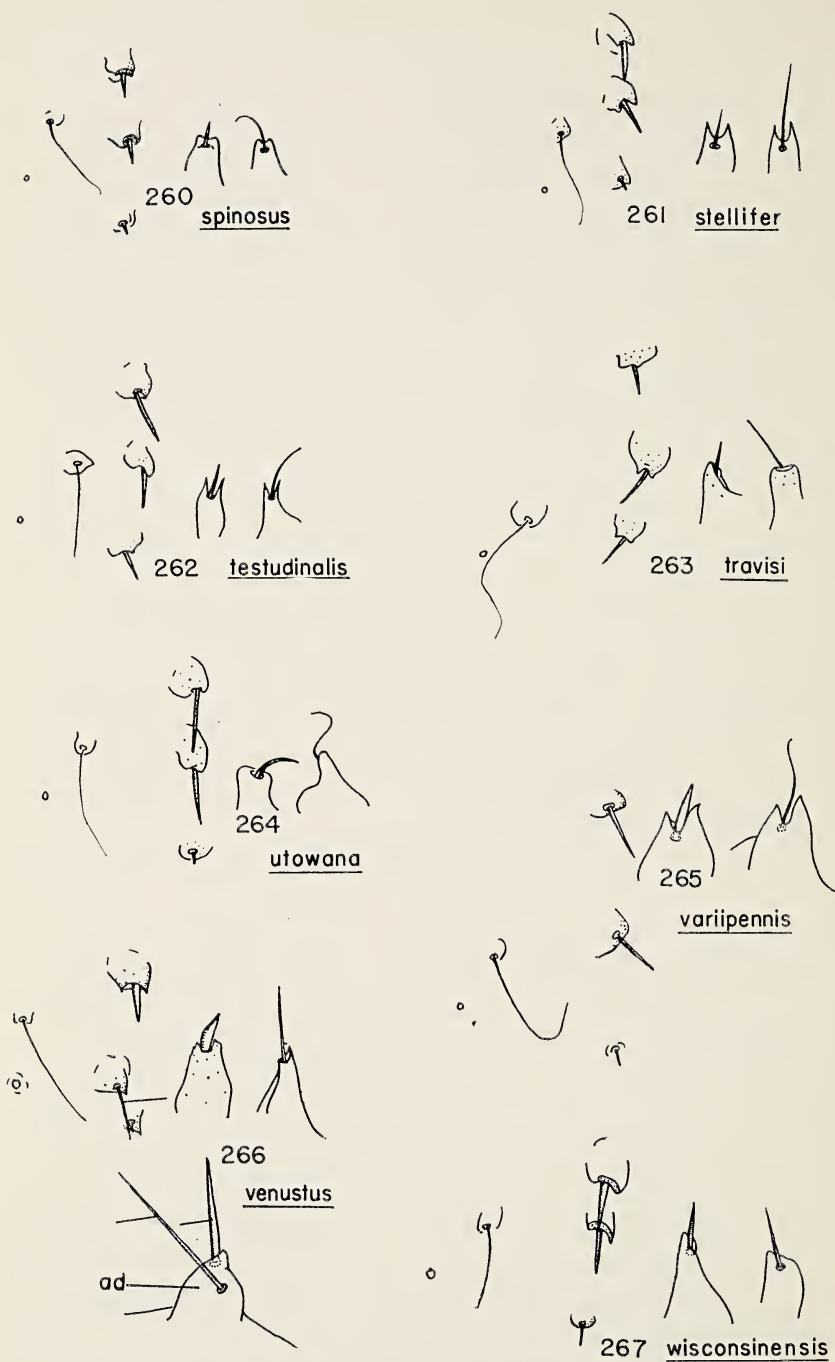


PLATE XXII. Figures 260-267, pupal tubercles and spines (*d* and *lpm* tubercles).

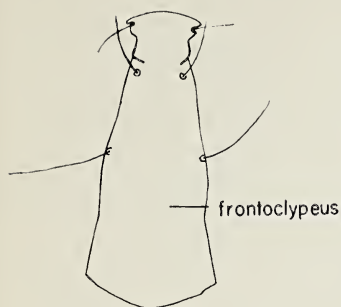
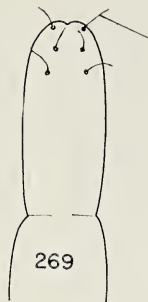
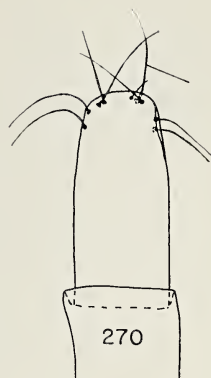
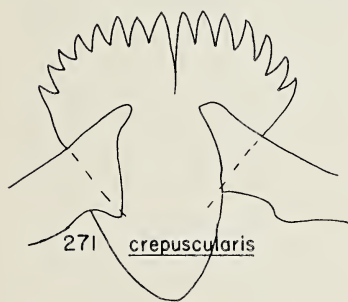
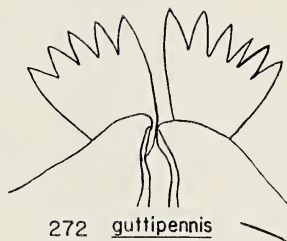
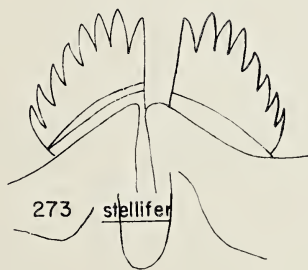
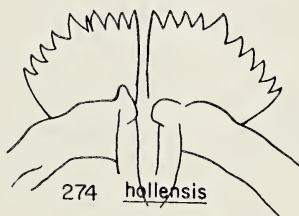
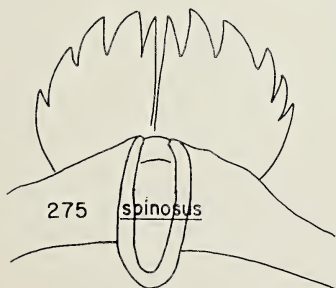
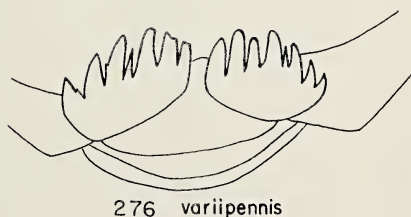
268 venustus269 hollensis270 guttipennis271 crepuscularis272 guttipennis273 stellifer274 hollensis275 spinosus276 variipennis

PLATE XXIII. Figure 268, larval frontoclypeus; Figures 269, 270 larval abdomen, terminal segments and setae; Figures 271-276 larval combs.

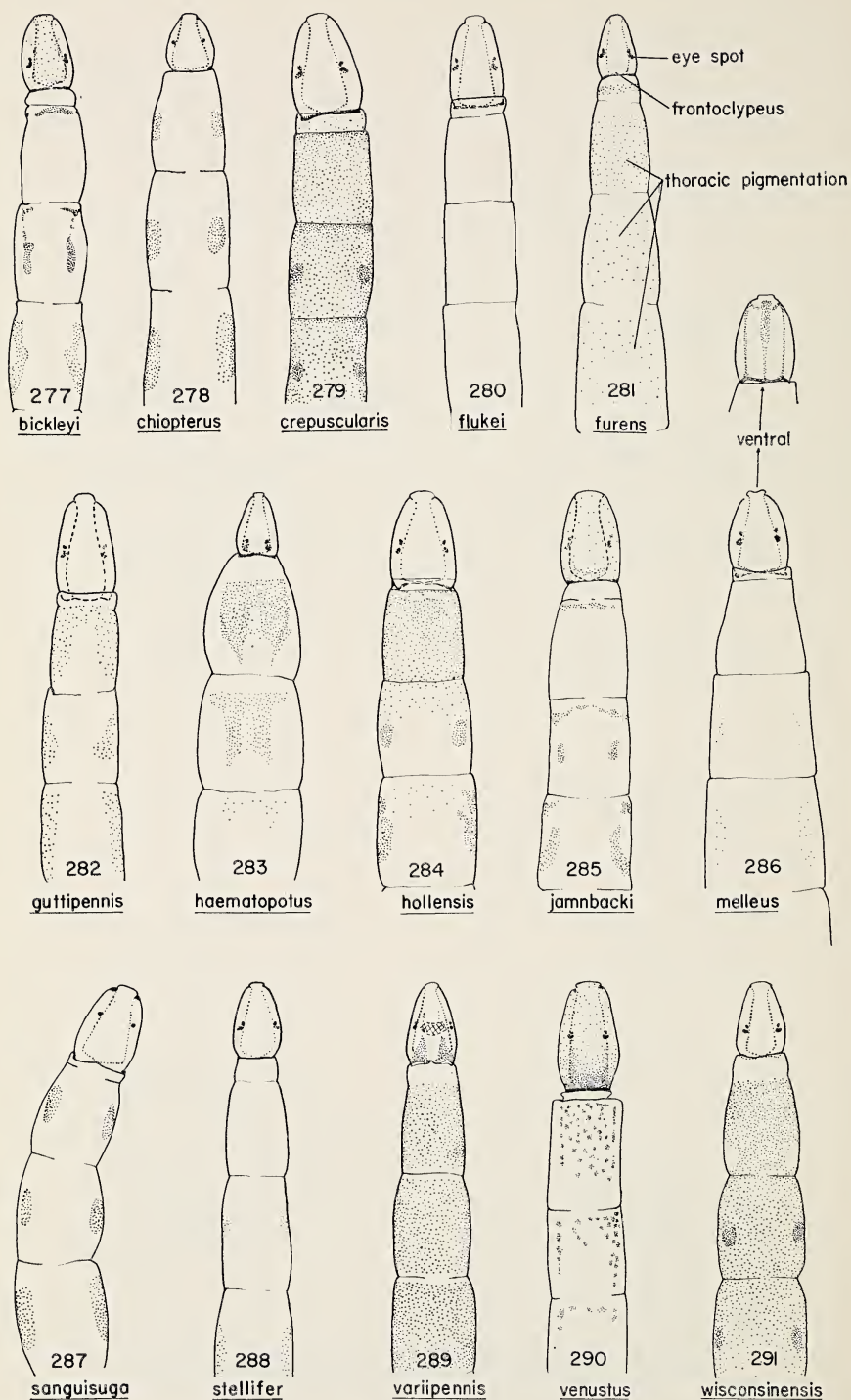


PLATE XXIV. Figures 277-291, larval heads and thoraces.

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A Synopsis of the North American Galerucinae (Coleoptera: Chrysomelidae)

by

John A. Wilcox

Associate Curator of Entomology
New York State Museum and Science Service

BULLETIN NUMBER 400

NEW YORK STATE MUSEUM AND SCIENCE SERVICE

*The University
of the State
of New York*

ALBANY, NEW YORK

*The State
Education
Department*



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79	Genus <i>Phyllecthris</i>
81	Genus <i>Luperosoma</i>
83	Genus <i>Trachyscelida</i>
84	Subtribe Monoleptina
84	Genus <i>Calomicrus</i>
91	Genus <i>Eusattodera</i>
93	Subtribe Luperina
94	Genus <i>Scelida</i>
97	Genus <i>Androlyperus</i>
100	Genus <i>Pseudoluperus</i>
116	Genus <i>Synetocephalus</i>
126	Genus <i>Scelolyperus</i>
160	Genus <i>Lygistus</i>
163	Genus <i>Keitheatus</i>
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A Synopsis of the North American Galerucinae (Coleoptera: Chrysomelidae)

By **John A. Wilcox***

ABSTRACT

KEYS ARE PROVIDED for the 212 species of Galerucinae from the United States and Canada, also descriptions and illustrations of many of the species. There are descriptions of the new genera, *Ophraella* (type: *Galleruca notata* Fabricius), *Brucita* (type: *Galerucella marmorata* Jacoby), *Lygistus* (type: *Lygistus streptophallus* n. sp.), and *Keithetus* (type: *Scelolyperus blakeae* White), and the new species, *Eusattodera delta*, *Scelida mimula*, *Pseudoluperus fulgidus*, *P. linus*, *P. wallacei*, *Scelolyperus carinatus*, *S. chautauquus*, *S. curvipes*, *S. hatchi*, *S. liriophilus*, *S. megalurus*, *S. phenacus*, *S. phoxus*, *S. ratulus*, and *Lygistus streptophallus*. The new name *Calomicrus blakeae* is substituted for the homonym *Luperodes pallidulus* Blake and *Chthoneis bowditchi* for *Scelolyperus rosenbergi* Bowditch. Tribes, subtribes, and genera in the Galerucinae are redefined.

* Submitted for publication February 13, 1964.

Introduction

THE GALERUCINAE constitute one of the larger subfamilies of the Chrysomelidae. The present synopsis includes 212 species from continental United States and Canada. Although the nearctic faunal region is usually considered to extend into Mexico, the Mexican Galerucinae are so poorly known that it seems more practical to limit the present study to the political boundary between Mexico and the United States rather than the more nebulous boundary of a faunal region.

This subfamily contains several species of economic importance. Species of *Diabrotica*, *Acalymma*, *Cerotoma*, *Erynephala*, *Monoxia*, *Calomicrus*, and *Galerucella*, have been cited in the literature of economic entomology.

The present study began in an attempt to determine the correct generic names for some of the New York State beetles. It quickly became apparent that the literature would give no easy solution, so the study was extended to a consideration of the galerucine genera of the whole world. This paper is the first of a series which is planned to cover world fauna not already monographed.

The taxonomic units in this paper have been given very uneven treatment. Certain groups have been revised recently by Doris H. Blake, and there is little or

nothing to add now. The species in these groups are keyed out and cataloged, but no description of them is included, unless there is some new observation to record. Reference is made to the published revisions where the reader can find more detailed information. Other groups, such as *Scelolyperus*, are so completely revised here that all available information is presented.

Acknowledgments

ASSISTANCE IN THE form of pertinent comments and the opportunity of examining specimens has come from many individuals and institutions. The author would like particularly to thank the following who have permitted examination of Galerucinae under their care: John C. Pallister, American Museum of Natural History (AMNH), New York, N.Y.; George E. Wallace, Carnegie Museum (CARNEGIE), Pittsburgh, Pa.; Hugh Leech, California Academy of Sciences (CAS), San Francisco, Calif.; Henry Dybas, Chicago Natural History Museum (CHICAGO), Chicago, Ill.; W. J. Brown, Canadian National Collection (CNC), Ottawa, Ontario, Canada; Henry Dietrich, Cornell University (CORNELL), Ithaca, N.Y.; R. R. Dreisbach (DREISBACH), Midland, Mich.; D. D. Millspaugh, Iowa Wesleyan College (IOWA), Mount Pleasant, Iowa; Fred A. Lawson, formerly at University of Kansas (KANS), Manhattan, Kans.; P. J. Darlington, Museum of Comparative Zoology (MCZ), Harvard University, Cambridge, Mass.; J. N. Knull and Charles A. Triplehorn, Ohio State University (OSU), Columbus, Ohio; J. A. G. Rehn and Harold J. Grant, Academy of Natural Sciences of Philadelphia (PHILA), Philadelphia,

Pa.; Floyd G. Werner, University of Arizona (ARIZ), Tucson, Ariz.; Lawrence H. Rolston, University of Arkansas (U.ARK.), Fayetteville, Ark.; Richard Alexander, University of Michigan (U.MICH.), Ann Arbor, Mich.; Doris H. Blake and George Vogt, United States National Museum (USNM), Washington, D.C.; Melville H. Hatch, University of Washington (U.WASH.), Seattle, Wash.; Robert F. Ruppel, Michigan State University, East Lansing, Mich.; and Ray F. Smith, University of California, Berkeley, Calif.

Finally, most grateful acknowledgment is expressed to Victor H. Cahalane and Donald L. Collins, New York State Museum (NYSM), Albany, for encouragement during a long and protracted project; and to Mrs. Margaret Slater for help in the preparation of this paper.

The location of a specimen recorded in this paper is indicated by an abbreviation of the name of the institution or person who owns the collection in which the specimen is deposited. These abbreviations are listed above with the acknowledgments. For example, the New York State Museum collection is (NYSM), the J. A. Wilcox collection is (W).

Bibliographic Citations

BIBLIOGRAPHIC citations used here list series, volume or year, number or part, and page number in that order, when they are applicable, after the abbreviated name of the periodical. For example, "Ann. Mag. Nat. Hist. (3)16(94):264" means *Annals and Magazine of Natural History*, series 3, volume 16, number 94, page 264. If other abbreviations are included—such as fasc. (fascicle), sect. (section), pl. (plate), and fig. (figure)—a less abbreviated form of the citation is employed. Periodical title abbreviations used in this bulletin are listed on page 212.

Additional notations in parentheses after page number or figure indicate the contents of the article. Abbreviations used for this purpose include biol. (biology), larva (description of larva), and r. (range). Recorded host plant names and localities may also be included within the parentheses. Notations within brackets are the present writer's comments and not those of the cited author.

Sections of this paper pertaining to particular specimens (e.g., holotype or specimens examined) call for a word of explanation. The data is, in large part, that taken directly from the labels on the specimens and is primarily quoted material. The sequence of information may be changed but the spelling and abbreviations are not. This policy leads to considerable inconsistency but reduces the chance of introducing errors, particularly when dealing with unfamiliar localities.

Taxonomy

GALERUCINAE ARE Coleoptera which may be defined, at least in North American, by the following combination of characters. All tarsi with five segments, of which the fourth is extremely small and appears to be merely a small basal part of the fifth. Third tarsal segment emarginate, the ventral pubescent pad usually distinctly bilobed. Antennae shorter than body, filiform, moniliform or clavate, never capitate; some segments modified in males of a few species. Antennae with 11 segments, except in male *Phyllecthris* which has 10; moderately closely set between the eyes, not on distinct tubercles. Eyes round or oval, not emarginate. Head normal, not prolonged into a distinct beak; with frontal tubercles behind the antennal insertions, delimited posteriorly by a more or less distinct, transverse, interocular groove. Head more or less inserted in prothorax, without a neck-like constriction at base. The aedeagus consists of a more or less cylindrical median lobe with a small Y-shaped tegmen lying below it, without parameres encircling the median lobe. (In this paper the term *aedeagus* is used to refer to the median lobe only.) The larvae are subterranean "rootworms" or leaf feeders. The latter usually live on the leaf surface, although in *Monoxia* they are leaf miners.

The combination of characters listed above also applies to the Alticinae, which are very closely related to Galerucinae. Some authors include them in the Galerucinae as a tribe, perhaps correctly so if uniformity in the higher categories is to be maintained. However, for the practical reason of maintaining tradition and of providing a larger number of standard suprageneric categories, the Alticinae are here considered to be a subfamily. Similarities between larvae of certain alticine and galerucine groups may be more closely tied to habitat than to actual ancestral identity.

The Alticinae can be distinguished from Galerucinae by the sclerotized extensor apodeme in the posterior femora of the former. This is a hard, hook-shaped piece which connects the extensor muscle with the basal portion of the tibia. It apparently is involved in the leaping ability of flea beetles. It is not found in any of the Galerucinae. There is also a much smaller flexor apodeme which occurs in certain species of both Galerucinae and Alticinae. It lies below or behind the extensor apodeme or extensor muscle and connects the flexor muscle with the tibia.

Orthaltica and *Leptotrichaltica* from the United States, *Micrepitrix* Laboissiere from the Oriental Region, and *Micrantipha* Blackburn from Australia seem to be the only exceptions to the rule. They appear to be flea beetles which lack the extensor apodeme.

Division of the Galerucinae into tribes or subtribes has been neither satisfactory nor consistent. Chapuis, 1875, divided the "Galerucides" into 27 groups (using the ending *-ites*). Horn, 1893, listed 11 of Chapuis' groups from North America and added two new ones. Leng, 1920, followed Horn but raised each of the groups to tribes. Weise revised the tribal classification in 1923 and published the Galerucinae part of the *Coleopterorum Catalogus* in 1924. He defined eight tribes on the basis of the condition of the tarsal claws and front coxal cavities. Most subsequent authors have vaguely followed Weise, frequently remarking on the inadequacy of the system. Laboissiere, 1921-1940, continued to use a large number of groups. Böving, 1927, working with larvae, suggested the subfamily be divided into two tribes which more or less overlap with the two major divisions of the Alticinae. His division is virtually a separation of rootworms from leaf-feeders.

The 4,000 species of Galerucinae form a subfamily which is difficult to handle because of its homogeneity and very large size. The author is preparing a world catalog of the Galerucinae and along with it, a revision of their taxonomy. This revision is a radical departure from any previous one, because the classification in the present study is based on male characters. As a result, in this book genera and especially tribes are defined in a manner different from those in previous literature. Descriptions and keys presented here apply to both male and female, except where otherwise specifically stated. Agreement of the classification with Böving's work on a few larvae is encouraging, but the difficulty in placing female specimens in their proper tribe is still disconcerting.

TENTATIVE KEY TO TRIBES OF GALERUCINAE

- 1 Aedeagus with prominent basal spurs (figure 14); or if
 without spurs, is constricted just before basal margin
 (figure 15); last ventral abdominal segment never
 with an apical lobe 2
- Aedeagus lacking prominent basal spurs (figure 56);
 or if with spurs, is not constricted just before basal
 margin (figure 63); last ventral abdominal segment

- of male nearly always with a distinct rectangular or curved apical lobe 3
- 2 Last ventral abdominal segment of male with a median, apical semicircular depression; apex may be emarginate behind depression; tarsal claws usually bifid; anterior and posterior tibiae rarely with apical spurs; larvae on leaves *Galerucini*
- Last ventral abdominal segment of male without a distinct depression, may be flattened; tibiae usually with spurs; claws usually appendiculate; larvae unknown *Metacyclini*
- 3 Last ventral abdominal segment of male with a short, evenly rounded apical lobe (figure 136); margin of basal foramen of aedeagus nearly circular (figure 132); larvae on leaves *Sermylini*
- Apical lobe of last ventral abdominal segment rectangular or absent (figures 71, 146) 4
- 4 Coronal suture usually distinct; mandibular teeth short, blunt; form large, broadly oval; if more slender, then the lateral pronotal margin is absent; elytral epipleura distinct only on basal fifth, except in *Botanoc-tona*; tibiae never with apical spurs; larvae on leaves *Oidini*
- Coronal suture rarely visible; mandibular teeth usually acute; form various; tibiae usually with apical spurs; larvae subterranean *Luperini*

Key to the North American genera of Galerucinae

- 1 Tarsal claws bifid or simple (figures 7, 124) 2
- Tarsal claws appendiculate (figure 122) 25
- 2(1) Anterior coxal cavities open 3
- Anterior coxal cavities closed; elytra coarsely punctate; body oval in form, 6.5-12 mm. long *Galeruca* Muller (p. 57)
- 3(2) Posterior tibia without an apical spur; or if a spur is present, then the elytra are densely and finely pubescent; pronotum at base nearly as wide as elytra; aedeagus with prominent basal spurs 4
- Posterior tibia with an apical spur; elytra glabrous or with a few, scattered, erect hairs; elytra distinctly wider than pronotum at base; aedeagus without prominent basal spurs 20

- 4(3) Large, 13 mm. or longer.....*Monocesta* Clark (p. 20)
 Smaller, less than 12 mm. long; or with striped elytra 5
- 5(4) Small, less than 4 mm. long; elytra glabrous or with only
 a few scattered hairs, color black or dark metallic
 blue, green, or bronze; all tibiae without apical
 spurs; Fla., Tex. to Ariz.....*Miraces* Jacoby (p. 55)
 Larger or without the combination of characters de-
 scribed above; middle tibiae of male with a broad,
 curved apical spur (except in *Pyrrhalta nymphaeae*) 6
- 6(5) Tarsal claws simple 7
 Tarsal claws bifid 8
- 7(6) Length 6-8 mm.....*Erynephala* Blake (p. 48)
 Length less than 6 mm.....*Monoxia* Leconte (p. 50)
- 8(6) Aedeagus long, flat, C-shaped with apex strongly deflexed;
 dull testaceous and black; female with simple tarsal
 claws*Erynephala* Blake (p. 48)
 Aedeagus normal, not deflexed; if apex of aedeagus is
 strongly deflexed, then basal third is cylindrical, not
 flattened 9
- 9(8) Pronotum very short, broad; width equal to two and a
 half times the length at middle; aedeagus short,
 truncate.....*Derospidea* Blake (p. 30)
 Pronotum longer in proportion to width; aedeagus
 pointed or rounded, not truncate at apex 10
- 10(9) Elytra unicolorous reddish or yellowish brown, usually
 with faint but distinct green luster; antennae long;
 segments 3 and 4 equal in length; 7.5-8 mm. long;
 Tex.....*Coraia* Clark (p. 32)
 Elytra not colored as above; if with metallic luster,
 then the margin is pale 11
- 11(10) Base of pronotum strongly sinuate; head, body, and
 elytra black; pronotum red with black median spot;
 elytra glabrous; 7.5 mm. long; Ariz.
Ophraea Jacoby (p. 47)
 Base of pronotum not strongly sinuate; if elytra are
 entirely black, they are also densely pubescent 12
- 12(11) Third antennal segment longer than fourth 13
 Third antennite shorter than fourth
Trirhabda Leconte (p. 22)
- 13(12) Elytra testaceous, may be spotted or mottled with black;
 antennae short, not reaching beyond humerus; abdo-
 men of male usually with a deflexed pygidium; west-

- ern States, Fla.....*Monoxia* Leconte (p. 50)
 Color variable, rarely mottled or spotted; antennae usually reach nearly to middle of elytra; abdomen of male without pygidium 14
- 14(13) Front coxae narrowly but distinctly separated by the prosternum; middle coxae separated by a distance sub-equal to one-half the coxal width; pronotum polished and nearly impunctate, except in the depressions; all tibiae lacking apical spurs in both male and female; aedeagus long, moderately curved, with apex and orifice symmetrical; 4.5-6 mm. long; throughout United States and Canada; on *Nuphar*, *Polygonum*, and *Myrica*
Pyrrhalta subgenus *Galerucella* Crotch (p. 34)
 Front coxae not separated by prosternum; middle coxae closely approximate but rarely in actual contact; male with a broad, often curved, apical spur on middle tibiae 15
- 15(14) Apical spurs lacking on hind tibiae of male; elytral pubescence even, not accentuating color pattern 16
 Male with apical spurs on middle and hind tibiae, also a tubercle at base of first segment of front tarsus; aedeagus symmetrical, strongly deflexed in apical third, tapering to an acute point; elytra dark testaceous with two slightly darker stripes, one submarginal and one running longitudinally along middle of each elytron, also three faint subsutural spots; surface of elytra densely pubescent, the pale areas accentuated by the arrangement of pale pubescence; 5-6 mm. long; Tex.....*Brucita*, new genus (p. 42)
- 16(15) Elytra with distinct dark stripes 17
 Elytra without distinct dark stripes 18
- 17(16) Elytra pale yellow (darker in overwintering form) with a broad black stripe extending from humerus nearly to apex, also usually with a short subscutellar stripe; elytra without darkened suture or subsutural stripe; aedeagus short, thick; apex asymmetrical, point to the right side; 6-6.5 mm. long; throughout United States and southeastern Canada; on elm (*Ulmus*)
Pyrrhalta subgenus *Xanthogaleruca* Laboissiere (p. 36)
 Elytra pale, each with at least three dark stripes, one of which is subsutural (*bivittata* Blatchley, with only

- submarginal and subsutural stripes, may belong here also); aedeagus long, slender, slightly curved, symmetrical; 3.5-6.5 mm. long; throughout United States; on Compositae. . . . *Ophraella*, new genus (p. 43)
- 18(16) Outer margin of epipleura (marginal bead between disc of elytron and epipleuron) may become obscure near apex, but inner margin (next to body) always distinct to apex or to point where it joins outer margin; fourth antennite distinctly longer than second 19
- Inner margin of elytral epipleuron remaining distant from outer margin and ending rather abruptly before apex; antennite 4 about as long as 2; aedeagus with orifice and lightly sclerotized area above it covering nearly half of dorsal surface; 3-4 mm. long; Canada, Mich.; on Rosaceae
- Pyrrhalta* subgenus *Neogalerucella* Chujo (p. 36)
- 19(18) Aedeagus symmetrical, orifice very near apex, small, without weakly sclerotized area above it; body oval, usually strongly convex; 4.5-6.5 mm. long; eastern United States; on *Solidago* (Compositae)
- Ophraella*, new genus (p. 43)
- Aedeagus strongly asymmetrical, apex with point turned to left; orifice large with a weakly sclerotized area above it; body usually more oblong, not as convex; 4-6.5 mm. long; throughout United States; on plants from various families
- Pyrrhalta* subgenus *Tricholochmaea* Laboissiere (p. 37)
- 20(3) Elytra dark metallic blue or green, except for narrow pale lateral and apical margins; male with antennites 5, 6, and 7 twice as wide as 4 or 8; elytra in male with a large depression across suture at apical fourth. *Paratriarius* Schaeffer (p. 63)
- Elytra not dark metallic blue or green or without color pattern of *P. dorsatus* above; male elytra and antennae not modified 21
- 21(20) Fifth ventral abdominal segment of male with prominent, rectangular, median apical lobe; apical segment of maxillary palp as long as, and usually nearly as wide as, the penultimate segment; form more elongate and parallel; Ariz. to Calif. . . . *Triarius* Jacoby (p. 165)
- Fifth ventral abdominal segment of male truncate or vaguely emarginate, without median apical lobe; apical segment of maxillary palp usually distinctly

- shorter, more slender at base than penultimate segment; form more oval, usually widest behind middle of elytra 22
- 22(21) Pronotum with a rather small, deep, circular impression on each side of middle, separated by a distance greater than the diameter of the impression; pronotum pale with a small black spot on each side; each elytron pale with suture and discal stripe black; Ariz.
Amphelasma Barber (p. 72)
- Pronotum evenly convex or with larger, shallow depressions; depressions usually separated by a distance less than their diameters; pronotum entirely pale or dark, without small spots 23
- 23(22) Each elytron pale with suture and a broad discal stripe black or brown; third antennal segment at least twice as long as second, nearly as long as fourth
Acalymma Barber (p. 70)
- Elytra entirely dark or pale, maculate, or vittate; if vittate, then third antennal segment is little longer than second, second and third together not so long as fourth 24
- 24(23) Antennite 3 small, not more than one and a half times length of 2; 2 and 3 together not so long as 4
Diabrotica subgenus *Diabrotica* Chevrolat (p. 64)
- Antennite 3 larger, at least twice as long as 2, about as long as 4
Diabrotica subgenus *Paranapiacaba* Bechyné (p. 68)
- 25(1) Front coxal cavities closed 26
 Front coxal cavities open 28
- 26(25) Antennite 3 distinctly longer than 4; elytra red or testaceous with black markings, without metallic luster; antennites 3 and 4 modified in males of some species
Cerotoma Chevrolat (p. 76)
- Antennite 4 distinctly longer than 3 27
- 27(26) Elytra with strong metallic blue or green luster; pronotum entirely pale; apical spurs on mid and hind tibiae but not on front tibiae; body and legs yellow; apex of last ventral abdominal segment of male with a very short, broad, evenly rounded, apical lobe; aedeagus without orificial plate; 5-7 mm. long (doubtfully recorded from North America)
Sermylassa Reitter (p. 173)

Elytra pale or dark brown, may have faint blue luster;
but if so, then the pronotum is as dark as elytra or
strongly alutaceous; apical spurs on all tibiae; orifice
of aedeagus covered with a sclerotized plate

Calomicrus Stephens (p. 84)

- 28(25) Elytral epipleura well defined 29

Elytral epipleura extremely narrow, indistinct

Phyllobrotica Chevrolat (p. 169)

- 29(28) Prothorax with lateral marginal bead 30

Prothorax without lateral marginal bead; head and pro-
notum yellow; elytra black with yellow suture and
margins, sutural yellow stripe not reaching apex but
bending away from suture on each side just before
apex; 4.5-6 mm. long; Tex.

Metrobrotica Bechyné (p. 75)

- 30(29) Elytral punctures in more or less regular rows between
raised carinae 31

Elytral punctures not in rows; elytra may have weak
carinae 32

- 31(30) Small, less than 4 mm. long; testaceous, brown or
black; elytra usually distinctly pubescent; on sumac
or poison ivy (both in *Rhus*)

Orthaltica and *Leptotrichaltica* in Alticinae

Larger, 5.3-6.7 mm. long; upper surface yellow, each
elytron with 6 or 7 small, dark spots; third antennal
segment at least twice as long as second; Ariz.

Neobrotica Jacoby (p. 73)

- 32(30) Middle tibia with a deep, inner, subapical notch 33

Middle tibia without subapical notch 34

- 33(32) Antenna with only 10 segments; segment 3 nearly four
times length of 2.....*Phyllecthris* Dejean (p. 79)

Antenna with 11 segments; segment 3 not or only
slightly longer than 2.....*Luperosoma* Jacoby (p. 81)

- 34(32) Elytra with an incisure within a depression on margin
at apical angles.....*Androlyperus* Crotch (p. 97)

Elytral margin without incisure or depression 35

- 35(34) Second ventral abdominal segment with two prominent
appendages 36

Ventral abdominal segments without appendages 37

- 36(35) Upper surface shining testaceous; elytra with suture and
a narrow lateral stripe dark; 4-4.5 mm. long; Calif.

Synetocephalus Fall (p. 116)

- Elytra bright metallic blue or green; head and pronotum testaceous.....*Scelida* Chapuis (p. 94)
- 37(35) First tarsal segment of hind leg distinctly longer than the second and third together; antennite 3 about as long as 2; 4 is usually as long as 2 and 3 together; apical lobe of last ventral abdominal segment large, nearly square 38
- Tarsite 1 of hind leg shorter than 2 and 3 together; apical lobe of last ventral segment absent or much wider than long 39
- 38(37) Pronotum with a very distinct impression on each side of middle; aedeagus weakly sclerotized above base of orificial plate; Ariz.....*Eusattodera* Schaeffer (p. 91)
- Pronotal impressions indistinct or absent; aedeagus normally sclerotized at base of orificial plate
- Calomicrus* Stephens (p. 84)
- 39(37) Form broadly oval; length less than twice width; last ventral abdominal segment of male without distinct lobe at apex 40
- Form more elongate; length at least twice the width across widest part of elytra..... 41
- 40(39) Color entirely dark blue or purple; 6-7.5 mm. long; N.Y., N.J.....*Agelastica* Chevrolat (p. 176)
- Entirely testaceous, except for eyes and elytra which are black and mandibles which are brown; 5.5 mm. long; Ariz.....*Trachyscelida* Horn (p. 83)
- 41(39) Antennae short, reaching only a little beyond the humerus; antennites 2, 3, and 4 about equal in length and width; elytra brownish red varying to black; pronotum rather broad; 5-6 mm. long; Tex. to Utah to Calif.....*Pteleon* Jacoby (p. 168)
- Antennae longer, reaching to middle of elytra or farther or the body is much smaller..... 42
- 42(41) Male, last ventral abdominal segment with apex lobed, truncate, or feebly emarginate; aedeagus present... 43
- Female, last ventral abdominal segment evenly rounded 54
- 43(42) Aedeagus with prominent basal spurs, with apex symmetrical and orifice asymmetrical; last ventral abdominal segment slightly truncate at apex, nearly as in female; elytra testaceous with dark markings; Tex. to Calif.....*Malacorhinus* Jacoby (p. 60)
- Aedeagus without prominent basal spurs, orifice sym-

- metrical; last ventral abdominal segment lobed or distinctly truncate 44
- 44(43) Aedeagus curved upward (orifice is on upper side); apex flattened, bent forward; elytra striped..... 45
- Aedeagus straight or curved downward..... 46
- 45(44) Each elytron yellow with three narrow, black, discal stripes; 6.5-7.5 mm. long; Tex..*Triarius* Jacoby (p. 165)
- Each elytron dark with a broad, median, pale, longitudinal stripe; dark areas usually with green luster; 3-4.5 mm. long; Tex...*Keitheatus*, new genus (p. 163)
- 46(44) Aedeagus with apex asymmetrical, truncate, or broadly emarginate; elytra entirely dark..... 47
- Apex of aedeagus symmetrical, rounded, or pointed... 48
- 47(46) Last ventral abdominal segment broadly truncate, flattened, and depressed in apical half, without a distinct apical lobe; front femora not larger than middle femora.....*Scelolyperus* Crotch (p. 126)
- Last ventral abdominal segment with a more or less rectangular apical lobe, depressed and within an apical emargination of the segment; front femora larger than middle femora.....*Lygistus*, new genus (p. 160)
- 48(46) Orifice of aedeagus covered by a partially sclerotized plate which is usually bifid or broadly truncate at apex; small, yellow species..*Synetocephalus* Fall (p. 116)
- Orifice of aedeagus covered with a nonsclerotized membrane 49
- 49(48) Small, less than 3.5 mm. long; apical spurs on all tibiae
Synetocephalus Fall (p. 116)
- Larger, at least 3.5 mm. long; if only 3.5 mm. long, then apical tibial spurs lacking..... 50
- 50(49) Tibiae with apical spurs 51
- Tibiae without apical spurs 52
- 51(50) Aedeagus long; slender; evenly, strongly curved in lateral view; 6-8 mm. long; elytra dark in male, pale in female.....*Triarius* Jacoby (p. 165)
- Aedeagus broader, nearly straight or irregularly curved in lateral view; 3.5-5 mm. long; elytra metallic blue or green.....*Pseudoluperus* Beller & Hatch (p. 100)
- 52(50) Elytra dark brown or black, usually without any metallic luster; pronotum dark
Pseudoluperus Beller & Hatch (p. 100)
- Elytra testaceous or metallic blue or purple..... 53

- 53(52) Pronotum and head testaceous, elytra metallic blue or blue-green; 4.5-6.5 mm. long; Ariz.
Scelida Chapuis (p. 94)
 Pronotum dark, pale with a median dark spot or entirely pale; if entirely pale, then the elytra are pale also.....*Pseudoluperus* Beller & Hatch (p. 100)
- 54(42) Apical spurs on middle and hind tibiae..... 56
 No apical spurs on any tibiae 55
- 55(54) Pronotum pale; elytra metallic blue or green
Scelida Chapuis (p. 94)
 Pronotum and elytra black
Pseudoluperus Beller & Hatch (p. 100)
- 56(54) Front tibiae without apical spurs 57
 Front tibiae with apical spurs 59
- 57(56) Elytra at least partly pale....*Androlyperus* Crotch (p. 97)
 Elytra entirely dark 58
- 58(57) Third antennite twice as long as second; elytra black without green, blue, or bronze luster
Androlyperus Crotch (p. 97)
 Antennite 3 about one and one-half times as long as 2; elytra with faint green, blue, or bronze luster; head dark; tibiae and tarsi pale; 3.5-4.2 mm. long; Ariz.
Lygistus, new genus (p. 160)
- 59(56) Elytra entirely dark 60
 Elytra at least partly pale.. May be *Phyllecthris* Dejean (p. 79), *Luperosoma* Jacoby (p. 81), *Malacorhinus* Jacoby (p. 60), *Synetocephalus* Fall (p. 116), *Pseudoluperus* Beller & Hatch (p. 100), or *Keithatus*, new genus (p. 163).
- 60(59) Interocular sulcus fairly deep, distinct, throughout its length, distinctly delimiting the frontal tubercles behind; elytra may have metallic blue or green luster. May be *Scelolyperus* Crotch (p. 126) or *Pseudoluperus* Beller & Hatch (p. 100).
 Interocular sulcus indistinct, not distinctly delimiting frontal tubercles; elytra without metallic blue or green luster 61
- 61(60) Diameter of antennite 3, near apex, distinctly less than that of 2; length of beetle 3-4 or 5-6 mm.
Phyllecthris Dejean (p. 79)
 Diameter of antennite 3 about same as that of 2, length of beetle 4.3-5.2 mm.*Luperosoma* Jacoby (p. 81)

TRIBE GALERUCINI

THIS GROUP IS usually easily recognized by the form of the aedeagus and the last ventral abdominal segment in the male. The aedeagus has distinct and usually rather large basal spurs, formed by the thickened, produced margin of the basal foramen. In combination with this character, the apex of the last ventral abdominal segment of the male is truncate or emarginate, without any apical lobe but usually with a semicircular apical depression. This depression is, in most species, rather deep and strongly delimited, sometimes pit-like, sometimes very faint and obsolete.

Females are a little more difficult to distinguish. Like males, they have bifid claws; usually the head is large and convex; the coronal suture usually distinct, often impressed. Tibiae usually without spurs in female. Males in many genera have a short, wide, oblique spur only on middle tibiae. In most genera the upper surface is distinctly pubescent.

As here defined, the Galerucini contain most of the genera which Weise, 1924, placed in this tribe and part of the genera which he catalogued under Oidini. Leng's 1920 Galerucini, Atysini, and Coelomerini belong here except for the genus *Triarius* Jacoby. *Triarius* seems to fit better in the Luperini, in spite of the bifid tarsal claws.

As here defined, the Oidini is restricted to the Old World genera: *Oides* Weber, *Anoides* Weise, *Botanoctona* Fairmaire, *Oidomorpha* Laboissiere, *Ellopidia* Hincks, and *Drasa* Bryant. Most of these agree with the Galerucini in having bifid tarsal claws but differ in the male characters mentioned above. The last ventral abdominal segment is strongly, rectangularly lobed at apex; and the margins of the basal foramen of the aedeagus are not strongly thickened or produced into basal spurs. In much of their morphology they approach the Chrysomelinae.

GENUS MONOCESTA CLARK

Figure 9

Form oval; prothorax broad but not so wide as elytra. Head normal in male, convex, deflexed, much narrower than prothorax. Eyes small. Ocular sulcus and supratentoria indistinct. Coronal suture very broadly, deeply depressed. Interocular sulcus distinct, shallow. Frontal tubercles small, transverse or crescent shaped, separated from each other by a narrow groove which extends forward between antennae. Interantennal area flat with a median groove. Front trans-

verse in front of antennae, moderately swollen; anterior margin strongly declivous. Clypeus comparatively long; length nearly one-third of width. Labrum evenly rounded, densely pubescent with long hairs. Antennae reach middle of elytra; rather thick apical segments not much wider than basal ones; not modified in male. Antennite 2 small; 3 is three times length of 2; 4 is distinctly shorter than 3. Pronotum twice as wide as long; base and sides with marginal bead. Sides evenly rounded, convex; apex slightly emarginate. Surface with a very broad, deep, transverse depression; very finely pubescent. Scutellum oblong, convex, finely pubescent. Elytra about one-fifth wider than pronotum at base, strongly convex, not modified. Surface finely, densely pubescent; moderately, densely, confusedly punctate.

Epipleuron broad, convex under humerus; inner marginal bead disappearing behind humerus. Mandibular tooth 1 normal; 2 and 3 confluent forming a very broad, truncate apex of the mandible. Prosternum not produced between coxae; epimera distant; front coxal cavities open. Legs moderately long, rather thick; tibiae broadened at apex, with a deep, glabrous groove on outer side and a very thin carina in the groove. Apical spurs lacking from all tibiae in both male and female. All claws bifid.

Apex of last ventral abdominal segment of male broadly emarginate, without apical lobe but with a broad, deep, triangular depression just before apex. Aedeagus symmetrical, with small but very distinct basal spurs; orifice covered by a membrane; apex pointed.

This is a large neotropical genus. The only North American species (figure 9) is oval, moderately convex, broader behind, yellowish testaceous; elytra metallic blue, with a broad transverse testaceous band at middle, broader at suture and sides; the blue areas may be reduced so that the elytra are nearly entirely pale. The surface of the elytra is virtually glabrous, but under strong magnification a fine hair can be seen in each puncture. Length 10 to 16 mm. The larvae of *M. coryli* (Say) feed on leaves of elm (*Ulmus*) and hazel (*Corylus*).

Monocesta Clark

Monocesta Clark, 1865, Ann. Mag. Nat. Hist. (3)16(94):257, 264.

Type: *Monocesta imperialis* Clark, 1865; designated by Weise, 1924, Coleop. Cat., pars 78, p. 50.

coryli (Say)

Pa., Fla., Kans.

Galleruca coryli Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:455.

Coelomera coryli (Say), Leconte, 1883, Complete Writings T. Say

2:220.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17: 211.—Beutenmuller, 1890, Ent. Americana 6:176 (biol.).

Monocesta coryli (Say), Clark, 1865, Ann. Mag. Nat. Hist. (3)16:266.—Horn, 1893, Trans. American Ent. Soc. 20:61.—Blatchley, 1924, Florida Ent. 8:3.—Böving, 1929, Proc. U.S. Nat. Mus. 75(2):10, fig. (larva).—Blake, 1931, Proc. U.S. Nat. Mus., vol. 79, art. 2, pl. 1, fig.

GENUS TRIRHABDA LECONTE

Horn, 1893, described this genus as follows: "Head broad, moderately deeply inserted, eyes oval, convex and entire. Antennae slender, three joints the length of the body, first joint claviform, second small, but oblong, third not quite twice as long as the second, fourth longer than the third, joints 4-10 gradually decreasing in length, eleventh longer; labrum transverse, emarginate; maxillary palpi not very stout, last joint conical, acute, narrower than the preceding joint and about as long. Thorax much broader than long, widest at middle, the angles distinct, and more or less prominent; scutellum short, obtuse; elytra elongate, parallel, or slightly broader behind, distinctly margined at sides, the epipleurae narrow, but extending somewhat posterior to the middle; prosternum not prolonged between the coxae, these prominent and contiguous; middle coxae slightly separated in front, contiguous posteriorly; metasternal side-pieces moderately broad, narrower posteriorly. Legs moderate, the tibiae faintly grooved on the outer side, without spurs at tip; tarsi not long, the first joint as long, or a little longer than the next two; claws bifid, but somewhat dissimilarly in the sexes.

"It seems not to have been observed by those who have had occasion to study the genus, that the claws are somewhat dissimilar in the two sexes. In the male the claws are narrowly bifid at tip, while in the female they are more broadly bifid posterior to the tip, seeming almost to be toothed."

Trirhabda Leconte

Trirhabda Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 219. Type: *Trirhabda nitidicollis* Leconte, 1865; designated by Barber, 1931, in Blake, Proc. U.S. Nat. Mus. 79(2):3.

Trirrhabda Gemminger & Harold, 1876, Cat. Coleop. 12:3575 (error or emendation for *Trirhabda* Leconte). Blake, 1931, Proc. U.S. Nat. Mus. 79(2):1-36.

adela Blake

Md., Utah, Calif.

Trirhabda adela Blake, 1931, Proc. U.S. Nat. Mus. 79(2):14, fig.

- attenuata* (Say) Kans., B.C.
Galleruca attenuata Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:459.
Trirhabda attenuata (Say), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:220.—Horn, 1893, Trans. American Ent. Soc. 20:71.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):21, fig.
- bacharidis* (Weber) Coastal N.Y., Fla., La.
Galleruca bacharidis Weber, 1801, Observationes Ent., p. 57.—Fabricius, 1801, Syst. Eleuth. 1:480.—Olivier, 1808, Ent. 6:629 fig.
Trirhabda bacharidis (Weber), Blake, 1931, Proc. U.S. Nat. Mus. 79(2):12, fig.
- Trirhabda tomentosa* of Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:220.—Horn, 1893, Trans. American Ent. Soc. 20:65.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):12 (probably not *Galleruca tomentosa* Linnaeus).
- borealis* Blake Mass., Wash.
Trirhabda borealis Blake, 1931, Proc. U.S. Nat. Mus. 79(2):16 fig.
- borealis indigoptera* Blake N. Dak., Ill., Kans.
Trirhabda borealis indigoptera Blake, 1931, Proc. U.S. Nat. Mus. 79(2):17.
- caduca* Horn Calif.
Trirhabda caduca Horn, 1893, Trans. American Ent. Soc. 20:69.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):31, fig.
- canadensis* (Kirby) Maine, Calif.
Galleruca canadensis Kirby, 1837, Fauna Bor.-Americana, pt. 4 p. 219.
Trirhabda canadensis (Kirby), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:219.—Horn, 1893, Trans. American Ent. Soc. 20:67.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):13, fig.
Trirhabda canadensis var. *tomentosa* of Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:56.
- confusa* Blake Calif.
Trirhabda confusa Blake, 1931, Proc. U.S. Nat. Mus. 79(2):27, fig.
- convergens* Leconte Mich., Alta., N.Mex.
Trirhabda convergens Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:220.—Horn, 1893, Trans. American Ent. Soc. 20:70.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):18, fig.
- diducta* Horn Nev., Calif.
Trirhabda diducta Horn, 1893, Trans. American Ent. Soc. 20:70.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):25, fig.

- eriodictyonis Fall Utah, Calif.
Trirhabda eriodictyonis Fall, 1907, Canadian Ent. 39:243.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):24, fig.
- flavolimbata (Mannerheim) Calif.
Galleruca flavolimbata Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou 16(2):308.
Trirhabda flavolimbata (Mannerheim), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:220.—Horn, 1893, Trans. American Ent. Soc. 20:72.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):29, fig.
- geminata Horn N. Mex., Calif.
Trirhabda geminata Horn, 1893, Trans. American Ent. Soc. 20:68.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2)31, fig.—Blake, 1951, Jour. Washington Acad. Sci. 41:324, fig.
Trirhabda nigrohumeralis Schaeffer, 1905, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, p. 170.—Blake, 1951, Jour. Washington Acad. Sci. 41:324 (synonym of *geminata* Horn).—(Blake, 1931, Proc. U.S. Nat. Mus. 79(2):30. This description applies to *T. schwarzi* Blake.)
- gurneyi Blake Nev.
Trirhabda gurneyi Blake, 1951, Jour. Washington Acad. Sci. 41:326, fig.
- labrata Fall Calif.
Trirhabda labrata Fall, 1907, Canadian Ent. 39:242.—Blake, 1931, Proc. U.S. Nat. Mus. 79:28, fig.
- lewisii Crotch Mont., Colo.
Trihabda Lewisii Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:56.
Trirhabda lewisii Crotch, Horn, 1893, Trans. American Ent. Soc. 20:70.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):22, fig.
- luteocincta (Leconte) Calif.
Galleruca luteocincta Leconte, 1858, Proc. Acad. Nat. Sci. Philadelphia (2)4:88.
Trirhabda luteocincta (Leconte), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:220.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):26, fig.
- neoscotiae Blake N.S.
Trirhabda neoscotiae Blake, 1931, Proc. U.S. Nat. Mus. 79(2):17, fig.
- nigriventris Blake N. Mex.
Trirhabda nigriventris Blake, 1951, Jour. Washington Acad. Sci. 41:327, fig.

- nitidicollis Leconte Mont., Calif.
Trirhabda nitidicollis Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:219.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):23, fig.
- pilosa Blake B.C., Wyo., Calif.
Trirhabda pilosa Blake, 1931, Proc. U.S. Nat. Mus. 79(2):20, fig.
 —Banham, 1961, Proc. Ent. Soc. British Columbia 58:38-40 (on sagebrush, *Artemisia tridentata*).
- pubicollis Blake Tex.
Trirhabda pubicollis Blake, 1951, Jour. Washington Acad. Sci. 41:326, fig.
- schwarzi Blake N. Mex., Ariz.
Trirhabda schwarzi Blake, 1951, Jour. Washington Acad. Sci. 41:324, fig.
Trirhabda nigrohumeralis: sensu Blake, 1931, Proc. U.S. Nat. Mus. 79(2):30, fig.
- sericotrachyla Blake Calif.
Trirhabda sericotrachyla Blake, 1931, Proc. U.S. Nat. Mus. 79(2):28, fig.
- virgata Leconte N.S., Ala., S. Dak.
Trirhabda virgata Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:220.—Horn, 1893, Trans. American Ent. Soc. 20:66.—Blake, 1931, Proc. U.S. Nat. Mus. 79(2):15, fig.
- viridicyanea Blake Wis., Alta.
Trirhabda viridicyanea Blake, 1931, Proc. U.S. Nat. Mus. 79(2):19, fig.

Key to the species of *Trirhabda* Leconte

(Modified from Blake 1931)

- 1 Occipital and pronotal spots and elytral vittae brown or black without metallic luster 2
 - Occipital or pronotal spots or vittae or entire elytra, except for margin, dark with metallic luster..... 16
- 2 Dark markings of head, pronotum, and elytra black or very dark brown 3
 - Dark markings of head, pronotum, and elytra reddish brown; elytra with markings reduced; species of the arid southwest 34
- 3 Pronotal surface between coarse punctures smooth and shining 4
 - Pronotal surface between coarse punctures alutaceous 7

- 4 Elytra coarsely punctate, with short, very sparse pubescence; sutural vitta only a narrow darker border of sutural edge; lateral vitta narrow, more or less evanescent; pronotum usually coarsely punctate, not polished; 5.5-6.5 mm. long; Calif.....*caduca* Horn
 Elytra finely punctate, finely and densely pubescent... 5
- 5 Pronotum not depressed; sutural and lateral vittae usually united at apex; 6-9 mm. long; Rocky Mountains to Calif.; on *Gutierrezia*, *Chrysothamnus*, *Artemisia*... 6
 Pronotum depressed on each side; sutural and lateral vittae not united at apex; 6-7.5 mm. long; Nev.; on *Franseria**gurneyi* Blake
- 6 Body beneath entirely pale; 7-9 mm. long; Mont. to N. Mex. to Calif.; on *Gutierrezia*, *Chrysothamnus*, *Artemisia**nitidicollis* Leconte
 Metasternum and abdomen dark; 6-9.5 mm. long; N. Mex.; on sagebrush (*Artemisia tridentata*)
nigriventris Blake
- 7 Elytra with lateral and sutural vittae united before or slightly behind middle or with traces of median vitta coalescing with lateral vitta 8
 Elytra with lateral and sutural black vittae distinct and not united before apex, no median vitta..... 10
- 8 Large, 7-12 mm. long; elytra finely and densely pubescent, vittae coalescing shortly behind middle; N.Y. to Fla. to La.; on *Baccharis*.....*bacharidis* (Weber)
 Smaller, 5-9 mm. long; elytra not densely pubescent; usually on *Solidago* or other dry-land Compositae.. 9
- 9 Lateral and sutural elytral vittae usually distinct, with traces of a median vitta, sometimes coalescing, sometimes evanescent; pronotum densely and coarsely punctate; 5.5-7 mm. long; Tex. to Calif; on *Encelia*, *Bahia**geminata* Horn
 Lateral and sutural vittae united behind middle; pronotum with scattered coarse punctures; 6-9 mm. long; N.S. to Ala. to S. Dak.; on *Solidago*....*virgata* Leconte
- 10 Occipital spot small, oblong, not forming a transverse band or extending broadly down front; elytra densely pubescent, finely punctate; 7-10 mm. long; Maine to B.C. to Md. to Calif.; on *Solidago*; (figure 22)
canadensis (Kirby)
 Occipital spot either a wide transverse basal band or extending broadly down front 11

- 11 On close examination, vittae deep blue or green, although appearing black; body beneath mostly dark; 5.6-6.5 mm. long; N.S.; on *Solidago*.....*neoscotiae* Blake
Elytral vittae always entirely piceous or black; body beneath usually pale, often with a narrow dark margin, this occasionally widening..... 12
- 12 Scutellum usually with pale tip; elytra inconspicuously pubescent, finely punctate; 5-7.5 mm. long..... 13
Scutellum black; elytra distinctly pubescent and, except in *adela*, distinctly and coarsely punctate..... 14
- 13 Ventral surface dark; pronotum shining; 6-9.5 mm. long; N. Mex.; on sagebrush (*Artemisia*)...*nigriventris* Blake
Metasternum and abdomen pale with dark margins; pronotum not shiny; 5-7.5 mm. long; Mont. to Colo.; on *Chrysothamnus**lewisii* Crotch
- 14 Elytra densely pubescent, covering fine punctuation; 6-10 mm. long; Hudson Bay to Md. to Calif.; on *Solidago*, *Cirsium**adela* Blake
Elytra not densely pubescent, the coarse sculpture apparent 15
- 15 Robust, 6-9 mm. long; coarsely punctate; occipital spots usually widely oblong and extend down front; aedeagus broad with short tip; N.S. to Ga. to Ill. to Tex.; on *Solidago**virgata* Leconte
Slenderer, 5.5-8 mm. long; not so coarsely punctate; occipital spot a transverse basal band curving down front; aedeagus gradually narrowed at tip; Mass. to W. Va. to Wash.....*borealis* Blake
- 16 Pronotum conspicuously pubescent 17
Pronotum either entirely glabrous or very inconspicuously and sparsely pubescent 20
- 17 Abdomen entirely dark, except for last segment; elytra green, except for pale margin and small basal vitta not reaching middle; smaller, 4.5-6.8 mm. long; Wyo. to Calif.; on *Artemisia*.....*pilosa* Blake
Abdomen never entirely dark, usually pale with narrow darker margin; elytra, except for pale margin, entirely blue, bronze, or green or with lateral, sutural, and traces of median vittae; 5-8 mm. long..... 18
- 18 Pronotal spots large; pronotum coarsely punctate..... 19
Pronotal spots small; pronotum not densely punctate; 5-8 mm. long; Rocky Mountains, Great Plains; on *Artemisia*, *Solidago**attenuata* (Say)

- 19 Apex of aedeagus abruptly narrowed to acute tip; 6.8-8 mm. long; Calif.; on *Artemisia*....*sericotrachyla* Blake
 Apex of aedeagus gradually narrowed to acute tip; 7 mm. long; Tex.*pubicollis* Blake
- 20 Pronotum not alutaceous, more or less shining..... 21
 Pronotum distinctly alutaceous 29
- 21 Pronotal spots entirely without metallic luster, usually small or moderate in size 22
 Pronotal spots with metallic luster, usually large..... 26
- 22 Sutural vitta entirely absent or at most represented only by darkened sutural edges; lateral vitta often reduced to an elongate humeral spot; 5-9 mm. long; Utah to Calif.; on *Eriodictyon**eriodictyonis* Fall
 Lateral and sutural vittae well marked; sometimes a median vitta; sometimes elytra entirely dark, except for pale margin 23
- 23 Pronotum very smooth, not depressed, polished; spots usually small; elytra never with median vitta or entirely dark; 7-9 mm. long; Mont. to N. Mex. to Calif.; on *Gutierrezia*, *Chrysothamnus*, *Artemisia* (figure 3)
nitidicollis Leconte
 Pronotum somewhat depressed not so shining; spots usually moderate in size; elytra either with median vitta or entirely dark, except for margin..... 24
- 24 Elytra with long, dense silky pubescence covering the punctation; sometimes entirely green or blue, except for margin; sometimes vittate with median vitta; 7-8.5 mm. long; Calif.; on *Artemisia*.....*confusa* Blake
 Elytra with sparser, shorter pubescence; the punctation distinctly visible 25
- 25 Occipital spot black, narrowly oblong down front; elytra usually with short median vitta, never entirely dark; punctation fine; 6.5-9 mm. long; Nev. to Calif. to Oreg.; on *Eriodictyon**diducta* Horn
 Occipital spot with metallic luster, curving broadly over head, often forming transverse basal band; elytra entirely blue or green, except for margin and rather coarsely punctate; 5-8 mm. long; Calif.; on *Baccharis*, *Eriodictyon**flavolimbata* (Mannerheim)
- 26 Very brilliantly metallic, with broad shining blue or green occipital basal band and large, often contingent, lustrous pronotal spots; elytra inconspicuously pubes-

- cent and coarsely punctate, shining blue or green, except for margin; 6-7.5 mm. long; Calif.; on *Aplapappus*, *Adenostoma* *labrata* Fall
- Metallic luster more or less obscured by pubescence, the occipital band and pronotal spots not so lustrous, not usually so large; elytra distinctly pubescent and with finer punctation 27
- 27 Oval, elytra rather coarsely punctate, never vittate; pubescence not long and silky; 5-8 mm. long; Calif.; on *Baccharis*, *Eriodictyon* *flavolimbata* (Mannerheim)
- Parallel; elytra with long silky pubescence, sometimes vittate; 7-10.5 mm. long; Calif. 28
- 28 Large, 8.5-10.5 mm. long; abdomen mostly dark with metallic luster; pronotum much depressed, its large spots with distinct metallic luster; on *Artemisa*, *Aplopappus*, *Covillea* *luteocincta* (Leconte)
- Smaller, 7-8.5 mm. long; abdomen pale, sometimes with margin dark metallic; smaller spots of pronotum with indistinct metallic luster; on *Artemisia*.... *confusa* Blake
- 29 Elytra finely and inconspicuously punctate; body beneath entirely dark; scutellum often with pale tip 30
- Elytra rather coarsely punctate; body beneath usually more or less darkened (not in *borealis indigoptera*); scutellum always dark 31
- 30 Elytra inconspicuously pubescent; pronotal spots moderately large; lateral and sutural vittae usually distinct and united at apex, occasionally coalescing before apex; 5-7.5 mm. long; Mont. to Utah to N. Mex.; on *Chrysothamnus* *lewisii* Crotch
- Elytra with fine, white pubescence; three pronotal spots small, with median one situated nearer basal margin of pronotum than anterior margin; lateral and sutural elytral vittae usually coalescing behind middle of each elytron, rarely the attenuated median pale vitta extending much below middle; 5-8 mm. long; Rocky Mountains and Great Plains; on *Artemisia*, *Solidago attenuata* (Say)
- 31 Large, 6-8 mm. long; elytral vittae very dark, appearing black but with indistinct blue, purple, or rarely green hue; abdomen mostly pale; Ill. to Minn. to N. Dak.
- borealis indigoptera* Blake
- Smaller, 5-6.5 mm. long; elytral vittae or entire elytra

- with green or blue luster, more or less pronounced;
abdomen always dark 32
- 32 Elytral vittae inconspicuously green or blue, appearing
nearly black; N.S.; on *Solidago*.....*neoscotiae* Blake
Elytral vittae or entire elytra, except for margin with
distinct metallic luster; Great Lakes westward..... 33
- 33 Elytra usually entirely blue or green; the vittae in vittate
forms usually not united at apex; elytra only moder-
ately pubescent; body beneath dark, without metallic
luster, paler in vittate forms; Great Lakes to Alta.;
on *Solidago**viridicyanea* Blake
Elytra entirely green, except for margin, or in vittate
forms with wide lateral and sutural vittae united at
apex; densely pubescent; body beneath dark with
metallic luster; Alta. to Mich. to N. Mex.; on
Solidago*convergens* Leconte
- 34 Elytra coarsely punctate, very sparsely pubescent; 5.5-6.5
mm. long; Calif.*caduca* Horn
Elytra not coarsely punctate, finely and densely pubes-
cent 35
- 35 Pronotum densely and coarsely punctate; elytra usually
with median vitta or traces of it, or entirely reddish
brown or piceous; 5.5-7 mm. long; Tex. to Calif.; on
Encelia, Bahia*geminata* Horn
Pronotum sparsely and coarsely punctate; elytra never
with median vitta or entirely dark 36
- 36 Prothorax usually angulate, shining; elytra usually with
elongate humeral spot and usually with metallic lus-
ter; 5-9 mm. long; Utah to Calif.; on *Eriodictyon*
eriodictyonis Fall
Prothorax not angulate, alutaceous; elytra with only
small dark humeral spot, not with metallic luster;
small, 5-7 mm. long; Ariz. to N. Mex.; on *Brick-*
ellia*schwarzi* Blake

GENUS DEROSPIDEA BLAKE

Form oval, elytra slightly broader than prothorax at base. Head normal, large; eyes small. Ocular sulcus and interocular sulcus indistinct. Frontal tubercles flat, indistinct, each delimited behind by a very fine, curved groove. Frontal tubercles confluent with clypeus. Longitudinal frontal carina not apparent. Transverse frontal carina moderately declivous in front. Antenna slender, reaching to apical

fourth of elytra. Male with antennite 2 small; 3 nearly twice as long as 2; 4 distinctly longer than 3 but not so long as 2 and 3 together.

Pronotum at least twice as wide as long; sides moderately curved or slightly sinuate; surface moderately convex with a broad, shallow depression on each side. Lateral marginal bead distinct. Width of elytra at base about 1.4 times width of prothorax. Elytra covered with fine pubescence, which does not obscure punctation. Punctation fine, close, confused. Epipleura very narrow; outer margin, between disc of elytra and epipleuron, indistinct near base below humerus.

Prosternum not extending between coxae; front coxal cavities open. Legs normal, rather thick. Male middle tibia with a large, broad, flattened, curved apical spur. No spurs on other tibiae of male or any tibiae of female. Claws bifid. Last ventral abdominal segment of male with a broad, shallow, apical emargination; with a very broad, shallow, median, semicircular impression just before the emargination. Female last ventral segment with a small, median, apical notch. Aedeagus large; with basal spurs; apex symmetrical, broadly truncate; orifice asymmetrical, covered by a weakly sclerotized plate.

Length 6.5 to 9.5 mm. Found in eastern United States.

The species of this genus are quite similar to those of *Trirhabda* but differ in the shorter prothorax and the truncate aedeagus.

Derospidea Blake

Derospidea Blake, 1931, Proc. U.S. Nat. Mus. 79(2):32. Type:

Trirhabda brevicollis Leconte, 1865, by original designation.

brevicollis (Leconte) Pa., Fla., Mich., Kans.

Trirhabda brevicollis Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:221.—Horn, 1893, Trans. American Ent. Soc. 20:65-66.—Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Bull. 1, no. 9, p. 242.

Derospidea brevicollis (Leconte), Blake, 1931, Proc. U.S. Nat. Mus. 79(2):33, fig.

ornata (Schaeffer) Tex.

Trirhabda ornata Schaeffer, 1905, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, no. 6, p. 137.—Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, no. 9, p. 242.

Derospidea ornata (Schaeffer), Blake, 1931, Proc. U.S. Nat. Mus. 79(2):34, fig.

Key to the species of Derospidea Blake

Elytra vittate; dark markings of elytra black; 6.5-9.5 mm. long; N.Y. to Fla. to Ind. to Tex.; on orange and prickly ash (*Xanthoxylum*) (both in Rutaceae) (figure 2). *brevicollis* (Leconte)
 Elytra pale, each with a large basal and an apical blue spot, the basal spot extending narrowly along suture; 8 mm. long; Tex.
ornata (Schaeffer)

GENUS CORAIA CLARK**Figure 4**

Body oval; elytra distinctly broader than prothorax. Head normal, large; eyes small. Ocular sulcus and interocular sulcus indistinct. Frontal tubercles prominent but weakly delimited behind and at sides; separated by a narrow groove. Frontal tubercles confluent with clypeus. Longitudinal frontal carina not apparent. Transverse frontal carina moderately declivous in front. Antennae of male thick, long, reaching to apex of elytra; antennite 2 short; 3 more than twice the length of 2, as long as 4. Antennae of female a little shorter and more slender.

Pronotum nearly twice as wide as long; sides moderately curved. Surface moderately convex with a broad, shallow depression on each side; also a less distinct smaller, median depression at base; sparsely covered with fine pubescence. Lateral marginal bead distinct but very weak in anterior half. Scutellum large, truncate, or emarginate at apex. Elytra nearly 1.5 times width of prothorax at base; evenly, moderately convex; covered with fine, indistinct pubescence. Punctuation confused. Humeri prominent. Epipleura very narrow; outer margin, between disc of elytra and epipleuron, indistinct below humerus.

Prosternum not extending between coxae; front coxal cavities open. Legs normal, rather thick. Male middle tibia with thick apical spur which is hooked at tip. No spurs on other tibiae of male or any tibiae of female. Claws bifid. Last ventral abdominal segment of male broadly emarginate, strongly declivous in emargination but without any other indication of depression. Last ventral segment of female evenly rounded. Aedeagus short, thick, with basal spurs.

Coraia Clark

Coraia Clark, 1865, Ann. Mag. Nat. Hist. (3)16:257,323. Type:

Coraia maculicollis Clark, 1865, by monotypy.
 subcyanescens (Schaeffer)

Tex.

Trirhabda subcyanescens Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, no. 9, p. 241.

Coraia subcyanescens (Schaeffer), Blake, 1931, Proc. U.S. Nat. Mus. 79(2):35, fig.

GENUS PYRRHALTA JOANNIS

Pyrrhalta, as here conceived, is a large, worldwide genus which presents serious difficulties in several aspects of its classification and nomenclature. Most of the species described before 1873 were placed in the genus *Galeruca*. The only significant exception was *viburni* Paykull, a European species for which Joannis provided the name *Pyrrhalta* in 1866. *Pyrrhalta* was originally placed in *Galeruca* as a subgenus, but subsequent authors raised it to full generic rank or listed it as a subgenus of *Galerucella*.

Crotch described the genus *Galerucella* in 1873 to include *nymphaeae* Linnaeus, *sagittariae* Gyllenhal, *cavicollis* Leconte, *haematica* Leconte, *marginella* Kirby, and *punctipennis* Mannerheim. No type species was designated then. In 1893 Horn included 11 species, adding the *notata* group, the introduced *xanthomelaena*, and several species in the *cavicollis* group. He set the concept of the genus which has prevailed to the present time in North America. Linell recorded *marmorata* Jacoby from Texas in 1898. In 1924, Woods described the life histories of several northeastern species; Fall discussed their taxonomy, including descriptions of several new species. Hatch and Beller described *spiraeophila* in 1932, and Brown added three northern species in 1938.

Partition of the genus began in 1922 when Laboissiere provided the subgeneric name *Hydrogaleruca* for the *nymphaeae* group of species. In 1934 he gave the name *Xanthogaleruca* to the group containing *luteola* (= *xanthomelaena*). Maulik, in 1936, designated *nymphaeae* as type species of *Galerucella*. This automatically made *Hydrogaleruca* a junior synonym of typical *Galerucella*. Chujo recognized this synonymy in 1962 and provided the name *Neogalerucella* for the *tenella* group which had previously been considered to be typical *Galerucella*. Chujo included *Neogalerucella*, *Xanthogaleruca*, and *Pyrrhalta* as subgenera of *Galerucella*. Gressitt and Kimoto, 1963, recognized *Galerucella* as a full genus for the *nymphaeae* group only and listed *Xanthogaleruca*, *Tricholochmaea*, and the *Galerucella* of authors as synonyms of *Pyrrhalta*. *Neogalerucella* would fall into this group.

Differences between typical *Galerucella* and *Pyrrhalta* may seem to be quite significant at first glance, but some species are more or less intermediate and form links which connect the extremes. The groups *Galerucella*, *Pyrrhalta*, *Neogalerucella*, *Xanthogaleruca*, and

Tricholochmaea seem to be congeneric but still distinct enough to maintain as subgenera. Strict adherence to the law of priority would require that the name *Pyrrhalta* be applied to this genus as Gressitt and Kimoto have done.

Pyrrhalta Joannis

Galleruca (*Pyrrhalta*) Joannis, 1866, L'Abeille 3:82. Type: *Galleruca viburni* Paykull, 1778, by monotypy.

Galerucella subgenus *Pyrrhalta*: Weise, 1886, Naturgeschichte der Insecten Deutschlands 6(4): 621.—Chujo, 1962, Philippine Jour. Sci. 91:37.

Pyrrhalta: Weise, 1924, Coleop. Cat., pars 78, p. 61.—Laboisiere, 1934, Ann. Soc. Ent. France 103:74.—Gressitt & Kimoto, 1963, Pacific Ins. Monog. 1B, p. 438.

A thorough revision of this group of beetles is needed. The genus and subgenera are very poorly defined. Included North American species and subgenera are considered in the following sections. The key to the genera of Galerucinae in the fore part of this article includes a key to the subgenera of *Pyrrhalta*.

SUBGENUS GALERUCELLA CROTCH

Figures 18, 21

Body elongate oval; elytra distinctly broader than prothorax; head narrower than prothorax. Eyes small. Frontal tubercles slightly swollen, well delimited behind and at sides. Interocular sulcus visible only behind tubercles. Clypeus, between antennae, flat or depressed. Transverse clypeal carina distinct, moderately declivous in front. Antennae short, reaching to basal fifth of elytra; antennite 2 large; 3 almost twice as long as 2 but not so thick; 4 shorter than 3 but a little longer than 2.

Width of prothorax nearly twice the length; sides strongly sinuate. Surface moderately to weakly convex, very irregular; a large depression on each side of middle. Surface shiny, except in depressions where the punctation and pubescence are much more distinct. Scutellum broadly rounded or truncate. Elytra with sides parallel; moderately convex; surface distinctly, finely pubescent. Punctation confused. Elytra may have faint longitudinal carinae. Epipleurae rather wide, gradually narrowed, visible nearly to sutural angle. Outer marginal bead, between epipleura and disc of elytra, absent at base in front of humerus.

Prosternum extending between coxae. Front coxal cavities open. Legs normal in male; apical spurs absent from all tibiae of both male

and female. Claws bifid. Last ventral abdominal segment of male with a broad, shallow, apical emargination, before which is a large, very deep, semicircular depression. The depression reaches middle of the segment. Aedeagus long, slender, with large basal spurs; apex symmetrical or only slightly asymmetrical; orifice large, symmetrical, covered with a membrane.

The larvae feed on leaves of *Nuphar*, *Polygonum*, and *Myrica*. Pupation occurs on the leaf surface with the end of the abdomen of the pupa attached to the leaf.

The North American forms are all considered to belong to the single species *P. nymphaeae*, although they make up a rather heterogeneous group. They differ from similar species in the comparatively wide prosternum, lack of apical tibial spurs, and the long, slender, symmetrical aedeagus. Portions of the pronotum (between and around the depressions) are smooth and shiny. The elytra are usually black or dark brown with pale margins. Sometimes there is also a faint median, longitudinal, pale, elytral stripe.

Subgenus *Galerucella* Crotch

Galerucella Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, 1873, p. 55. Type: *Chrysomela nymphaeae* Linnaeus, 1758; designated by Maulik, 1936, Fauna Brit. India, Coleop., Chrys., Gal., p. 214. *Hydrogaleruca* Laboissiere, 1922, Revue Zool. Africaine 10:33. Type: *Chrysomela nymphaeae* Linnaeus, 1758, by original designation.

nymphaeae (Linnaeus) Throughout United States and Canada

Chrysomela nymphaeae Linnaeus, 1758, Syst. Nat., ed. 10:376.

Galerucella nymphaeae (Linnaeus), Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:55.—Horn, 1893, Trans. American Ent. Soc. 20:79.—Hamilton, 1889, Trans. American Ent. Soc. 16:149.—Schaupp, 1883, Bull. Brooklyn Ent. Soc. 6:54 (biol.).—Weise, 1924, Coleop. Cat., pars 78, p. 58 (much additional European literature cited here).

Galeruca femoralis Melsheimer, 1847, Proc. Acad. Nat. Sci. Philadelphia 3:161.

Galleruca marginella Kirby, 1837, Fauna Bor.-Americana, pt. 4, p. 308.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:217.

Galleruca sagittariae Gyllenhal *sensu* Kirby, 1837, Fauna Bor.-Americana, pt. 4, p. 219.

Galleruca luctuosa Mannerheim, 1852, Bull. Soc. Imp. Nat. Moscou 25:368.

SUBGENUS NEOGALERUCELLA CHUJO

Similar to typical *Galerucella* and previously placed in that subgenus. The very broad epipleuron is the most distinctive character of *Neogalerucella*. The inner marginal bead, which separates the epipleura from the ventral surface of the elytra, becomes obtuse and disappears near the apex. The two North American species are small, 3 to 4 mm. long. Elytra entirely testaceous; evenly, densely pubescent; coarsely punctate. Prosternum not extending between the coxae. Front coxal cavities open. Males have an apical spur on middle tibia; male of *quebecensis* (figures 11, 12) with a spur on front tibia also. The aedeagus is symmetrical, with large basal spurs; orifice covered by a membrane.

Species of this subgenus feed on leaves of plants in the Rosaceae.

Subgenus *Neogalerucella* Chujo

Galerucella subgen. *Neogalerucella* Chujo, 1962, Philippine Jour. Sci. 91:38. Type: *Chrysomela tenella* Linnaeus, 1761, by original designation.

stefanssoni (Brown) Canada (N.W. Territories)

Galerucella stefanssoni Brown, 1938, Canadian Ent. 70:36.—
Brown, 1952, Canadian Ent. 84:341.

quebecensis (Brown) Que., Mich.

Galerucella quebecensis Brown, 1938, Canadian Ent. 70:36.—
Brown, 1952, Canadian Ent. 84:341.

Key to the North American species of *Pyrrhalta* subgenus *Neogalerucella* Chujo

Fourth ventral abdominal segment black; apex of aedeagus not produced, blunt, almost truncate; 3-3.8 mm. long; front tibia of male without apical spur; N.W. Territories; on *Rubus chamaemorus*
stefanssoni (Brown)

Four ventral abdominal segment pale; aedeagus with apex long, tapering, produced (figures 16, 19); front tibia of male with an apical spur; 3.5-4 mm. long; N.S., Que., Mich.; on *Potentilla palustris*
quebecensis (Brown)

SUBGENUS XANTHOGALERUCA LABOISSIERE

Figures 25, 28

Similar to typical *Galerucella* and previously placed in that subgenus. This genus differs from *Pyrrhalta nymphaeae* as follows:

Body strongly convex. Prosternum not extending between coxae. Front coxal cavities open. Middle tibia of male with an apical spur. Aedeagus short, thick; apex asymmetrical, point to the right side; orifice large, covered by a membrane which has a small sclerotized point at apex. *P. luteola* (Muller), the notorious elm leaf beetle, is yellow or greenish yellow with a small basal stripe and a submarginal one which reaches from humerus nearly to apex (figures 25, 28). It is 6 to 6.5 mm. long. The larvae feed on leaves of elm (*Ulmus*). Pupation occurs on the surface of the ground or in crevices in the bark near the base of the tree trunk.

Subgenus *Xanthogaleruca* Laboissiere

Galerucella subgen. *Xanthogaleruca* Laboissiere, 1934, Ann. Soc. Ent. France 103:67. Type: *Chrysomela luteola* Muller, 1766, by original designation.

Gressitt & Kimoto, 1963, Pacific Ins. Monog. 1B, p. 438 (synonym of *Pyrrhalta* Joannis).

luteola (Muller)

Throughout United States

Chrysomela luteola Muller, 1766, Melang. Soc. Roy. Turin 3:187.

Galerucella luteola (Muller), Bedel, 1897, Faune Bassin Seine 5:163.—Silvestri, 1910, Boll. Lab. Zool. Portici 4:248, fig.—Reitter, 1912, Fauna Germanica 4:139.—Weise, 1924, Coleop. Cat., pars 78, p. 57 (Additional European literature cited under this name).

Galerucella (Xanthogaleruca) luteola (Muller), Laboissiere, 1934, Ann. Soc. Ent. France 103:67.

Pyrrhalta luteola (Muller), Gressitt & Kimoto, 1963, Pacific Ins. Monog. 1B, p. 455.

Chrysomela xanthomelaena Schrank, 1781, Enumeratio Insectorum Austriae Indigenorum, p. 78.

Galerucella xanthomelaena (Schrank), Horn, 1893, Trans. American Ent. Soc. 20:74, 81.—Garman, 1899, Kentucky Agric. Exp. Sta., Bull. 84, p. 65-72, fig. (biol.).—Chittenden, 1899, U.S. Dept. Agric., Bur. Ent., Bull. 19, pp. 80-85, fig.—Weise, 1924, Coleop. Cat., pars 78, p. 57 (synonym of *luteola* Muller).

SUBGENUS *TRICHOLOCHMAEA* LABOISSIERE

Similar to typical *Galerucella* and previously placed in that subgenus. The front coxal cavities are open; prosternum not extending between the coxae. Male with a broad apical spur on middle tibiae. Epipleura normal. The color may be red, testaceous, brown, or rarely

black but not vittate. Aedeagus strongly asymmetrical; apex usually with acute point turned to left; orifice large, asymmetrical, with a weakly sclerotized area above it. Body broader, more convex than in *Galerucella*, less convex than in *Ophraella*. The larvae feed on leaves of plants in various families. Pupation occurs underground.

The North American species, closely related to *cavicollis*, form a very homogeneous group, easily recognized by the form of the aedeagus (only *tuberculata* lacks the acute tip). The Japanese *Tricholochmaea semifulva* (Jacoby), the type species, differs only in lacking apical tibial spurs and in having a slightly less asymmetrical aedeagus. Since the differences are so slight, it would be better to lump the *cavicollis* group into *Tricholochmaea* rather than to provide a new name for it.

Hoplostines Blackburn from Australia is most closely related to *Tricholochmaea* but not close enough to be considered a synonym. It differs in its bright green elytra and well-delimited frontal tubercles.

Subgenus *Tricholochmaea* Laboissiere

Lochmaea subgen. *Tricholochmaea* Laboissiere, 1932, Bull. Mus. Hist. Nat., Paris (2)4:963. Type: *Galerucella semifulva* Jacoby, 1885, by original designation.

cavicollis (Leconte) Mass., N.J., Alta.

Galeruca cavicollis Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:216.

Galerucella cavicollis (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:76.—Cushman, 1916, U.S. Dept. Agric., Bull. 352.—Hartzell, 1917, New York Agric. Exp. Sta., Bull. 444, pp. 749-820, fig.—Blatchley, 1910, Coleop. Indiana, p. 1169.—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 86.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 133 (biol.).

Galeruca haemastica Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:216.

rufosanguinea (Say) Mass., N.Y., Va.

Galleruca rufosanguinea Say, 1827, Jour. Acad. Nat. Sci. Philadelphia 5(3):299.—Leconte, 1859, Complete Writings T. Say 2:343.

Galerucella rufosanguinea (Say), Horn, 1893, Trans. American Ent. Soc. 20:77.—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 86.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 133 (biol.).

Lochmaea rufosanguinea (Say), Weise, 1924, Coleop. Cat., pars 78, p. 80.

- tuberculata (Say) N.S., Miss., Iowa
Galleruca tuberculata Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3(2):456.—Leconte, 1859, Complete Writings T. Say 2:220.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:216.
 [*Galerucella tuberculata* (Say) *sensu* Horn, 1893, Trans. American Ent. Soc. 20:80. This is the pale form of *G. punctipennis* Mannerheim according to Fall 1924.]
Galerucella tuberculata (Say), Blatchley, 1910, Coleop. Indiana, p. 1169.—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 88.
- punctipennis (Mannerheim) B.C., Calif.
Galleruca punctipennis Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou 16(2):308.
Galerucella tuberculata (Say) *sensu* Horn, 1893, Trans. American Ent. Soc. 20:80.
Galerucella punctipennis (Mannerheim), Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 88.—Beller & Hatch, 1932, Univ. Washington Publ. Biol. 1(2):109.
- punctipennis pallida (Beller & Hatch) Wash.
Galerucella punctipennis ab. *pallida* Beller & Hatch, 1932, Univ. Washington Publ. Biol. 1(2):109.
- spiraeophila (Hatch & Beller) Wash., Ore.
Galerucella spiraeophila Hatch & Beller, 1932, Pan-Pacific Ent. 8:107.—Beller & Hatch, 1932, Univ. Washington Publ. Biol. 1(2):110.
- decora (Say) Northeastern United States and Canada
Galleruca decora Say, 1824, Long's Second Exped. 2:294.—Leconte, 1859, Complete Writings T. Say 1:195.
Galerucella decora (Say), Horn, 1893, Trans. American Ent. Soc. 20:80.—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 90.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 105, fig. (biol.).
Galleruca salicis Randall, 1838, Boston Jour. Nat. Hist. 2:31.
- decora carbo (Leconte) Manit., B.C., Kans., N. Mex.
Galeruca carbo Leconte, 1861, Proc. Acad. Nat. Sci. Philadelphia 13:358.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:217.
Galerucella decora var. *carbo* (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:80.—Hatch, 1933, Canadian Ent., 65:14.
Galerucella decora subsp. *carbo* (Leconte), Beller & Hatch, 1932, Univ. Washington Publ. Biol. 1(2):110.
- kalmiae (Fall) Maine, Mass., N.Y.
Galerucella kalmiae Fall, 1924, Maine Agric. Exp. Sta., Bull. 319,

- p. 87.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 127, fig. (larva, biol.).
- vaccinii* (Fall) Maine, Que., Mass.
Galerucella vaccinii Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 88.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 93, fig. (biol.).
- spiraeae* (Fall) Maine, Mass., Mich.
Galerucella spiraeae Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 89.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 122, fig. (larva, biol.).
- alni* (Fall) Maine, N.Y., Mich.
Galerucella alni Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 89.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 115, fig. (larva, biol.).
- perplexa* (Fall) Maine, Ont.
Galerucella perplexa Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 90.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 112 (biol.).
- ribicola* (Brown) Manit., Alta.
Galerucella ribicola Brown, 1938, Canadian Ent. 70:37.
- ribicola confusa* (Brown) Ont., Mich.
Galerucella ribicola subsp. *confusa* Brown, 1946, Canadian Ent. 78:50.

Key to the American Species of *Pyrrhalta* subgenus

Tricholochmaea Laboissiere

- 1 Side margins of elytra thickened or with a convexity between the declivity and the epipleural edge, most noticeable toward the base; color red; antennae black, pubescence sparse 2
 Side margins of elytra without or with but feeble indication of convexity (most noticeable in *kalmiae*) 3
- 2 Pronotum and elytra densely punctate and dull; body beneath and legs same color as upper surface; 5-5.3 mm. long; Mass. to Va.; on *Azalea* *rufosanguinea* (Say)
 Pronotum coarsely, less closely punctate, shining; antennae, tibiae, and tarsi usually black or dark brown; 4.2-5 mm. long; Mass. to N.J. to Alta.; on cherry (*Prunus*); (figures 26, 29) *cavicollis* (Leconte)
- 3 Male with excavation of last ventral segment very large, extending to, or nearly to, the base of the segment;

aedeagus long, slender; apex blunt, without acute point (figure 24); last ventral of female with a small narrow incisure at apex, from which a well-defined groove extends forward; color dull reddish brown; antennae, tibiae, and tarsi usually black; 5-6.5 mm. long; N.S. to Miss. to Iowa; on willow (*Salix*)

tuberculata (Say)

Male with excavation of last ventral segment shorter than length of segment; aedeagus broader, with an acute tip at apex; last ventral segment of female unmodified, except in some specimens of *spiraeae*....

- 4 Pronotum coarsely and discretely punctate and somewhat shining 4
 Pronotum densely, confusedly or rugosely punctate, dull 7
 5 Color red, antennae pale at base; 4.5-5.7 mm. long; Maine to Mass. to N.Y.; on *Kalmia*.....*kalmiae* (Fall)
 Color black; elytra may be pale 6
 6 Elytra entirely black; 6.5 mm. long; B.C. to Calif.; on willow (*Salix*)

punctipennis punctipennis (Mannerheim)

Elytra pale; humeri black

punctipennis pallida (Beller & Hatch)

- 7 Elytra without carinae or stripes 9
 Each elytron with two paler, less strongly punctured, slightly convex, longitudinal stripes 8
 8 Very pale brownish yellow; costae less distinct; 4.3 mm. long; Manit. to Alta.; on *Ribes*.

ribicola ribicola (Brown)

Brownish yellow, darker than the above form; costae more distinct; 4-4.7 mm. long; Ont. to Mich.; on

Ribes.....*ribicola confusa* (Brown)

- 9 Antennae, wholly or in great part, and legs entirely pale; form rather short and stout; color dull yellow, varying to reddish or brownish testaceous; 4-4.5 mm. long; Que. to Maine to Mass.; on *Vaccinium*

vaccinii (Fall)

Antennae in greater part fuscous or blackish; form narrower and more oblong 10

- 10 Body beneath pale, not black; abdomen may be brown; head pale or with a small dusky occipital spot 11
 Body beneath in great part black; the abdominal apex paler; head posteriorly broadly blackish 13

- 11 Color generally yellow or brownish yellow, pronotum with three, more or less distinct, dark spots; last ventral segment of female usually with a small narrow notch at apex; 4.3-5 mm. long; Maine to Mass. to Mich.; on *Spiraea* *spiraeae* (Fall)
 Color dark reddish brown; thorax without or with only vague and diffuse traces of discal spots; last ventral segment of female without apical incisure 12
- 12 Pronotum a little more roughly punctured, especially at the middle of the disc; second antennal segment relatively a little longer; claws as a rule more widely bifid; 4.8-5.2 mm. long; Maine to N.Y. to Mich.; on alder (*Alnus*) *alni* (Fall)
 Pronotum smoother than in allied species; the middle of the disc smoother than in *alni* but nearly as in *decora*; second antennal segment relatively shorter; claws more narrowly bifid; 5 mm. long; Maine to Ont. *perplexa* (Fall)
- 13 Elytra and pronotum entirely black or very dark brown; 5.5 mm. long; Manit. to B.C. to Kans. to N. Mex.; on willow (*Salix*) *decora carbo* (Leconte)
 Elytra at least partly pale yellowish brown 14
- 14 On *Spiraea*; elytra and pronotum entirely pale; elytral punctures on disc usually separated by a distance less than their diameters; surface between punctures alutaceous, dull; 5-5.5 mm. long; B.C. to Calif.
spiraeophila (Hatch & Beller)
 On willow (*Salix*); elytra often with disc darker than margin; pronotum usually with three black spots; elytral punctures on disc usually separated by a distance greater than their diameters; surface between punctures usually smooth, shining; 4.5-5.5 mm. long; northeastern United States and Canada to Alta.
decora decora (Say)

BRUCITA, NEW GENUS

Figures 17, 20

Similar to *Pyrrhalta* and previously placed in *Galerucella*. *Brucita marmorata* (Jacoby), the only species yet recognized, differs from *Pyrrhalta nymphaeae* in being much more convex and in possessing apical spurs on middle and hind tibiae of the male. The aedeagus is

symmetrical, strongly deflexed in apical third, tapering to an acute point; base with large spurs. Length 5 to 6 mm.

Type species: *Galerucella marmorata* Jacoby, 1886.

Jacoby, 1886, described *marmorata* as follows: "Larger and more robust than *G. fusco-maculata*, but almost identical in coloration; the head is covered with thin yellowish pubescence; the antennae are black, more robust, and the terminal joints are slightly thickened; the thorax is shaped as in *G. fusco-maculata*, but of a reddish colour, with three large round black spots occupying nearly the entire disc, the surface covered with fine silky yellow hairs, the usual depressions are present, but the punctuation is scarcely visible; the elytra are very finely (in one specimen) or more distinctly rugosely-punctured, covered with greyish hairs, and each marked with three broad longitudinal fuscous bands, the sutural one being interrupted before and below the middle by an obscure fulvous spot, a similarly coloured spot being visible at the apex, a longitudinal slightly raised narrow line (evidently caused by light-coloured pubescence), commencing at the shoulder but not extending quite to the apex, divides the other bands at some distance from the lateral margin; all the femora are marked with a piceous spot at the middle, and the apices of the tibiae are more or less fuscous."

Brucita, new genus

marmorata (Jacoby)

Tex., Mexico, Guatemala

Galerucella marmorata Jacoby, 1886, Biol. Centr.-Amer., Coleop.

6(1): 491, fig.—Linell, 1897, Proc. U.S. Nat. Mus. 20:484.

OPHRAELLA, NEW GENUS

Similar to *Pyrrhalta* and previously placed in *Galerucella*. The species differ from *Pyrrhalta nymphaeae* in being a little more convex; sides more curved. The color is pale yellowish brown, usually with narrow black elytral stripes, although in some species specimens may occur which are entirely pale. The pubescence of the elytra is even, rather dense in all species, except *cribrata* which is glabrous. Third antennite longer than the fourth. Prosternum not extending between front coxae; front coxal cavities open. Middle tibia of male with an apical spur; other tibiae and all tibiae of female lacking apical spurs. Last ventral abdominal segment of male very shallowly, broadly emarginate, with a deep pit very near the median apical margin. Aedeagus slender, evenly curved, symmetrical, with large basal spurs; orifice small, near apex, symmetrical, covered by a membrane. Length 3.5 to 6.5 mm.

Found in the eastern three-fourths of North America.

Species of this genus are apparently restricted to the Compositae for their host plants. Pupation takes place in a very loosely woven cocoon on the host plant.

Type species: *Galleruca notata* Fabricius, 1801.

This vittate group is quite distinct from the other groups previously placed in *Galerucella*. Of the named genera and subgenera, it is most closely related to *Erynephala*, *Monoxia*, *Yingaresca*, *Ophraea*, and *Schematiza*. *Erynephala* differs in the consistently simple-clawed females; the long, flat, bent aedeagus; and in the poorly defined elytral epipleura. The larvae are disconcertingly similar to those of *Ophraella* in morphology and habits. Most of the species of *Monoxia* differ from those of *Ophraella* in the simple claws of the female and leaf-mining habit of the larva. *Monoxia sordida*, *apicalis*, and *brisleyi*, which may belong in *Yingaresca* Bechyné, differ from *Ophraella* only in their slightly shorter antennae, slightly more evident pygidium, and the lack of an acute marginal bead separating the epipleura from the disc of the elytra. Their pronotum is usually deeply, broadly depressed on each side. *Ophraea* is quite similar to *Ophraella* in most respects but does differ in the very thin prosternal process which separates the front coxae, the short and densely punctate pronotum, the larger size, and the glabrous elytra. *Schematiza* is typically a group of flat beetles with explanate elytral and pronotal margins and broad, flat antennal segments. However, some of the species are far less extreme in these characters and exhibit a rather close resemblance to those of *Ophraella*.

Ophraella, new genus

Type species: *Galleruca notata* Fabricius, 1801.

americana (Fabricius) N.Y. to Fla. to Utah to Ariz.

Galleruca americana Fabricius, 1801, Syst. Eleuth. 1:489.

Galeruca americana Fabricius, Olivier, 1808, Ent. 6:636, fig.—
Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:215.

Galerucella americana (Fabricius), Horn, 1893, Trans. American
Ent. Soc. 20:74, fig.—Blatchley, 1910, Coleop. Indiana, p. 1167
(in part).—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 85.—
Woods, Maine Agric. Exp. Sta., Bull. 319, p. 137.

cribrata (Leconte) Maine to Va. to Colo.

Galeruca cribrata Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia
17:215.—Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia
25:55 (synonym of *americana*).

Galerucella cribrata (Leconte), Fall, 1924, Maine Agric. Exp. Sta.,

Bull. 319, p. 85.—Woods, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 137 (biol.).

sextvittata (Leconte) Eastern United States to Colo.

Galeruca sextvittata Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:215.

Galerucella sextvittata (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:76, fig.—Blatchley, 1910, Coleop. Indiana, p. 1168, fig.—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 85.

conferta (Leconte) Canada, Ill., Mich.

Galeruca conferta Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:215.

Galerucella conferta (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:74 (synonym of *americana*).—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 85 (valid species).

integra (Leconte) Pa., Fla., Tex.

Galeruca integra Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:218.

Galerucella integra (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:77, fig.

bivittata (Blatchley) Fla.

Galerucella bivittata Blatchley, 1920, Canadian Ent. 52:70.

notulata (Fabricius) Conn., Fla., Manit., Ariz.

Galleruca notulata Fabricius, 1801, Syst. Eleuth. 1:489.

Galeruca notulata Fabricius, Olivier, 1808, Ent. 6:636, fig.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:217.

Galerucella notulata (Fabricius), Jacoby, 1886, Biol. Centr.-Amer., Coleop. 6(1):489.—Horn, 1893, Trans. American Ent. Soc. 20:78, fig.—Blatchley, 1910, Coleop. Indiana, p. 1168.—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 86.

notata (Fabricius) Maine, Fla., N. Mex.

Galleruca notata Fabricius, 1801, Syst. Eleuth. 1:488.

Galeruca notata Fabricius, Olivier, 1808, Ent. 6:637, fig.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:218.

Galerucella notata (Fabricius), Horn, 1893, Trans. American Ent. Soc. 20:78, fig.—Blatchley, 1910, Coleop. Indiana, p. 1168.—Fall, 1924, Maine Agric. Exp. Sta., Bull. 319, p. 86.

bilineata (Kirby) Canada

Galleruca bilineata Kirby, 1837, Fauna Bor.-Americana, pt. 4, p. 220.

Galerucella bilineata (Kirby), Weise, 1924, Coleop. Cat., pars 78, p. 58 (synonym of *G. notulata* Fabricius).

Key to the species of the *Ophraella*, new genus

- 1 Body broadly oval and strongly convex; pronotum strongly convex with distinct lateral callosities, lateral depressions obsolete; aedeagus nearly symmetrical at apex 2
 Body more depressed; pronotum lacking definite lateral callosities, lateral depressions well defined. 3
- 2 Upper surface virtually glabrous; pronotum smoother and more shining, the punctation sparser and unevenly distributed; 5-6.5 mm. long; Maine to Va. to Colo.; on Goldenrod (*Solidago*) *cribrata* (Leconte)
 Upper surface conspicuously pubescent with a mixture of erect and subrecumbent hairs; pronotum densely and rugosely punctate; 4.5-6 mm. long; N.Y. to Fla. to Utah to Ariz.; on *Solidago* . . . *americana* (Fabricius)
- 3 Each elytron with three or four narrow black stripes. 4
 Each elytron with a broad submarginal and a narrow subsutural stripe; antennae and occiput black; 4.5 mm. long; Fla.; on *Gaylussacia* (?) *bivittata* (Blatchley)
- 4 Each elytron with three narrow discal stripes. 5
 Each elytron with four stripes; the second stripe from suture may be very short or joined to the subsutural one 6
- 5 Form narrower; sides nearly parallel; elytra moderately and closely punctate, evidently pubescent; aedeagus not narrowed at middle (figure 12); 4.5-5.5 mm. long; eastern United States to Colo.; on *Solidago* *sextivittata* (Leconte)
 Form broader; sides arcuate; elytra more coarsely and densely punctate, virtually glabrous; aedeagus narrowed at middle (figure 13); 4.7 mm. long; Mich. to Ill. to Canada. *conferta* (Leconte)
- 6 Second elytral stripe long, nearly reaching elytral apex; 3.5-5.8 mm. long; Fla. *integra* (Leconte)
 Second elytral stripe short, not extending much beyond middle of elytra 7
- 7 Second elytral stripe reaches middle of elytra, usually joining subsutural stripe; 3.5-4.5 mm. long; Conn. to Fla. to Man. to Ariz.; on ragweed (*Ambrosia*) *notulata* (Fabricius)
 Second elytral stripe basal, very short, about one-sixth the length of elytra (figure 11); 4-5 mm. long; Maine to Fla. to N. Mex.; on boneset (*Eupatorium*) *notata* (Fabricius)

GENUS OPHRAEA JACOBY**Figures 27, 30**

Fall, 1910, described *Ophraea arizonica* as follows: "Oblong oval, black, prothorax rufous with median elongate black spot; surface dull, the elytra with sparse exceedingly short and scarcely visible pubescence; punctuation of upper surface very dense, the punctures in actual contact or very nearly so throughout, coarser on the prothorax and basal parts of the elytra, becoming gradually finer apically. Antennae less than half the length of the body, third and fourth joints equal. Prothorax fully twice as wide as long, widest behind the middle, sides arcuately convergent in front, the anterior angles minutely prominent, suddenly sinuate behind the point of greatest width, becoming parallel for a short distance at base; hind angles rectangular, base obliquely sinuate each side, disk rather deeply tri-impressed. Elytra nearly six times as long and one-half wider than the prothorax, one-half longer than wide, surface somewhat uneven, a vague sublateral sulcus, bounded externally by an obtuse rounded ridge extending from the humerus nearly to the apex. Beneath dull, finely sparsely punctate and feebly wrinkled, last ventral with an obscure pale spot occupying a feeble depression on each side."

In addition to the characters mentioned by Fall, the following apply to *Ophraea arizonica*. Width of elytra across humeri about 1.2 times greatest width of pronotum. Frontal tubercles moderately swollen, well delimited. Clypeus short, flat between the antennae. Transverse clypeal carina prominent, acute, very strongly declivous in front. Antennite 2 is small; 3 is one and one-half times as long as 2; 3 and 4 are equal in length.

Epipleura moderately wide at base, gradually narrowed from base to apical angles. Outer marginal bead, between epipleuron and disc of elytron, indistinct at base below humerus. Prosternum extending narrowly between coxae. Front coxal cavities open. Male with a short, broad, apical spur on middle tibiae. Other tibiae and all of those of female without spurs. Claws bifid.

Last ventral abdominal segment of male very broadly, shallowly emarginate. Apical margin of segment, within the emargination, thickened and provided with a small, deep hole. Aedeagus with basal spurs; apex symmetrical, pointed; orifice asymmetrical, not covered by a sclerotized plate.

Length 7.5 to 8 mm.

This genus is apparently most closely related to the *Ophraella* but differs from that genus by the prosternum separating the front coxae, the **larger** size, and the larger less symmetrical aedeagal orifice. It

differs from *Galerucella* in its larger size and more convex form and in having apical spurs on the middle tibiae of the male. One species is known from the United States (figures 26, 29), others from Central America.

Ophraea Jacoby

Ophraea Jacoby, 1886, Biol. Centr.-Amer., Coleop. 6(1):492.

Type: *Ophraea rugosa* Jacoby, 1886, by present designation.

Iugosa Jacoby

Ariz., Mexico, Guatemala

Ophraea rugosa Jacoby, 1886, Biol. Centr.-Amer., Coleop. 6(1):493, fig.

Ophraea arizonica Fall, 1910, Trans. American Ent. Soc. 36:147.

—Blake, 1957, Proc. Ent. Soc. Washington 59:278, fig. (on *Beloperone*).—New synonymy.

GENUS ERYNEPHALA BLAKE

Body elongate oval; prothorax slightly narrower than elytra. Body moderately convex; upper surface pale yellowish brown. Each elytron may have one or two black stripes or may be black with pale margins. Elytra and scutellum covered with fine, dense pubescence.

Head normal in male and female. Vertex very closely punctate. Coronal suture usually distinct and darkened. Ocular and interocular sulci indistinct. Frontal tubercles small, slightly convex, poorly delimited behind by a very shallow sulcus which runs to the antennal socket on each side. Interantennal carina broad, flat. Genae longer than one-half the length of the eye. Antenna short, not reaching much beyond humerus; not modified. Third antennite about twice as long as second, distinctly longer than fourth.

Pronotum one and one-half times as wide as long, widest at base, distinctly narrower at apex; sides evenly curved. Surface moderately convex; with broad, shallow, irregular impressions; with coarse and close punctation. Scutellum nearly square, slightly narrower at apex, densely pubescent. Elytra about one-sixth wider than pronotum at base. Sides nearly straight in basal half. Surface moderately convex, not modified; punctation moderate to coarse, very closely, irregularly placed. Pubescence fine, not obscuring the punctation.

Epipleuron and disc of elytron separated by an evenly rounded ridge lacking the usual, acute, marginal bead. Epipleura wide at base, very gradually narrowed behind, distinct beyond apical angles of elytra.

Prosternum not extending between or behind front coxae. Front coxal cavities open. Mesosternum not extending between middle coxae. Legs normal, rather thick. Male with a thick, curved, apical spur on each middle tibia but without one on front and hind tibiae. Female without any apical tibial spurs. Tarsal claws of male bifid. Tarsal claws of female simple. Last ventral abdominal segment of male truncate at apex, without an apical lobe but with a small, median depression at apical margin. Last ventral segment of female with a small, median notch on apical margin. Aedeagus very long, slender, flattened, C-shaped; base with distinct spurs; orifice small, more or less symmetrical, covered by a membrane.

Length 6.8 to 9 mm.

These beetles are found along the coasts of both the Atlantic and Pacific Oceans and in the Rocky Mountain region. They are closely related to *Ophraella*, but differ in the strongly curved aedeagus of the male and the simple claws of the female. They are much larger than any species of *Monoxia*, which also has simple claws in the female.

Erynephala Blake

Erynephala Blake, 1936, Jour. Washington Acad. Sci. 26:425.

Type: *Galeruca maritima* Leconte, 1865, by original designation.
puncticollis (Say) Manitt., Idaho, Tex., Mexico

Galleruca puncticollis Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:458.

Monoxia puncticollis (Say), Horn, 1893, Trans. American Ent. Soc. 20:83 (in part).—Chittenden and Marsh, 1920, U.S. Dept. Agric., Bull. 892, pp. 1-24, fig. (desc., biol., bibliog.).—Böving, 1929, Proc. U.S. Nat. Mus. 75(2):26, fig. (larva).

Erynephala puncticollis (Say), Blake, 1936, Jour. Washington Acad. Sci. 26:426, fig.

Galeruca erosa Leconte, 1885, Trans. American Ent. Soc. 13:28.
—Horn, 1893, Trans. American Ent. Soc. 20:83 (synonym of *puncticollis*).

morosa (Leconte) Calif.

Galleruca morosa Leconte, 1857, preprint of 1860, Reports Expl. and Surv. for Railroad from Mississippi R. to Pacific Ocean, vol. 9, pt. 3, no. 1, p. 70.

Galeruca morosa, Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:219.

Erynephala morosa (Leconte), Blake, 1936, Jour. Washington Acad. Sci. 26:427, fig.

maritima (Leconte) Coastal N.S. to Fla. to Tex., Jamaica
Galcruca maritima Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:218.

Erynephala maritima (Leconte), Blake, 1936, Jour. Washington Acad. Sci. 26:428, fig.

Monoxia puncticollis var. *texana* Schaeffer, 1932, Canadian Ent. 64:237.—Blake, 1936, Jour. Washington Acad. Sci. 24:429 (doubtfully placed under *maritima*).—Blake, 1963, in *litt.* (a form, not a subspecies, of *maritima*).

Key to the North American species of *Erynephala* Blake

(Modified from Blake 1936)

- 1 Elytra markedly wider than prothorax and covered with short, fine pubescence somewhat obscuring the punctation; pronotum usually somewhat depressed with deep, coarse punctures; 8-9 mm. long; Manít., Idaho, Mexico *puncticollis* (Say)
 - Elytra not much wider than prothorax; pubescence only moderately dense with punctation not at all obscured; pronotum not depressed and more shallowly punctate; maritime species 2
- 2 Pubescence on head and elytra distinct and rather long; frontal tubercles on head well marked; 7 mm. long; Calif. *morosa* (Leconte)
 - Pubescence on head and elytra short, not at all conspicuous; frontal tubercles on head indistinctly marked; 6.8-7.5 mm. long; coastal N.S. to Tex. (figures 6, 7, 23) *maritima* (Leconte)

GENUS MONOXIA LECONTE

Figure 8

These small beetles are similar to *Erynephala* and *Ophraella* in appearance, and the description of *Erynephala* will fit them, except for the following characters. Frontal tubercles indistinct. Genae longer than in *Erynephala*, may be as long as long diameter of eye. Third antennal segment about one and one-half times as long as second. Punctation of pronotum and elytra usually fine. Acute marginal bead which separated the epipleuron from disc of elytron distinct in some species, indistinct in others. Epipleura narrow. Females of most of the species have simple tarsal claws. In this respect they agree with the species of *Erynephala*; however, they are much

smaller, 2.5 to 5.3 mm. long and the aedeagus is moderately curved, not strongly C-shaped as in *Erynephala*.

Females with bifid tarsal claws and males, all of which have bifid claws, are extremely similar to *Ophraella*, particularly *O. notulata* (Fabricius). Their antennae reach only to the humeri and are thus shorter than in *Ophraella*. Dark markings on the elytra of *Ophraella* consist of regular stripes, although they may be faint. Dark markings on the elytra of *Monoxia* consist of irregularly placed, small spots which may run together to form irregular blotches but not regular stripes.

Species of *Monoxia* are found in the arid or semiarid regions of the western United States and Canada and in Mexico. The few recorded larvae of this genus are leaf miners on plants belonging to the families Compositae and Chenopodiaceae. These larvae are quite distinctive and bear comparatively little resemblance to those of *Ophraella* and *Erynephala*.

Monoxia Leconte

Monoxia Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:221.

Type: *Galleruca angularis* Leconte, 1859; designated by Blake, 1939, Proc. U.S. Nat. Mus. 87:146.

Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):145.

sordida group

apicalis Blake Ariz., Calif.

Monoxia apicalis Blake, 1939, Proc. U.S. Nat. Mus. 87 (3072): 170, fig.

brisleyi Blake Ariz., Utah, Calif.

Monoxia brisleyi Blake, 1939, Proc. U.S. Nat. Mus. 87(3072): 171, fig.

sordida (Leconte) Tex., Colo., Calif.

Galleruca sordida Leconte, 1858, Proc. Acad. Nat. Sci. Philadelphia 10:88.

Monoxia sordida (Leconte), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:210.—Horn, 1893, Trans. American Ent. Soc. 20:86.—Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):155, fig.

angularis group

angularis (Leconte) N. Dak., B.C., Calif.

Galleruca angularis Leconte, 1859, Proc. Acad. Nat. Sci. Philadelphia 11:90.

Monoxia angularis (Leconte), Leconte, 1865, Proc. Acad. Nat.

- Sci. Philadelphia 17:221.—Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):156, fig.
- Monoxia consputa*: Horn, 1893, Trans. American Ent. Soc. 20:85 (in part; not Leconte 1865).
- batisia* Blatchley Fla., Tex., Mexico
Monoxia batisia Blatchley, 1917, Canadian Ent. 49:273.—Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):151, fig. (*batisii*).
- consputa* (Leconte) Tex., Wyo., Calif.
Galleruca consputa Leconte, 1857, preprint of 1860, Reports Expl. and Surv. for Railroad from Mississippi R. to Pacific Ocean, vol. 9, pt. 3, no. 1, p. 70.
- Monoxia consputa* (Leconte), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:222.—Horn, 1893, Trans. American Ent. Soc. 20:85 (in part).—Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):152, fig.
- debilis* Leconte Kans., Alta., Ariz.
Monoxia debilis Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:222.—Horn, 1893, Trans. American Ent. Soc. 20:85-86.—Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):159, fig.
- Monoxia obtusa* Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:222.—Horn, 1893, Trans. American Ent. Soc. 20:86 (synonym of *debilis* Leconte).
- elegans* Blake N. Mex., Colo., Oreg.
Monoxia elegans Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):164, fig.
- grisea* Blake Mont., Idaho, Alta.
Monoxia grisea Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):163, fig.
- guttulata* (Leconte) Calif.
Galleruca guttulata Leconte, 1857, preprint of 1860, Reports Expl. and Surv. for Railroad from Mississippi R. to Pacific Ocean 9(1):70.
- Monoxia guttulata* (Leconte), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:222.—Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):153, fig.
- Monoxia consputa* in the sense of Horn, 1893, Trans. American Ent. Soc. 20:85 (in part; not Leconte, 1865).
- inornata* Blake Kans., N. Mex., Alta.
Monoxia inornata Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):162, fig.
- minuta* Blake Ariz.
Monoxia minuta Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):169, fig.

- obesula Blake Tex.
Monoxia obesula Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):
 167, fig.
- pallida Blake Colo., Idaho
Monoxia pallida Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):
 168, fig.
- puberula Blake Tex., Calif., Alta.
Monoxia puberula Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):
 165, fig.
- schizonycha Blake Colo., Wash., Calif.
Monoxia schizonycha Blake, 1939, Proc. U.S. Nat. Mus. 87(3072):
 166, fig.

Key to the species of *Monoxia* Leconte

(Blake 1939)

- 1 Claws in both sexes bifid 2
 Claws in female simple, in male bifid 5
- 2 Head without pronounced median vertical depression;
 prothorax not twice as broad as long; elytra strongly
 and moderately coarsely punctate; medium size,
 3.5-4 mm. long; Colo. to Wash. to Calif.; on sugar
 beet, *Chrysothamnus* *schizonycha* Blake
 Head with pronounced median vertical depression; pro-
 thorax short and fully twice as broad as long; elytra
 finely punctate; smaller, 2.5-3.8 mm. long..... 3
- 3 Densely pubescent, punctuation of elytra hidden; apex of
 aedeagus seen from above broad with a short, pointed
 tip; Tex. to Colo. to Calif.; on *Lycium*, *Gutierrezia*,
 Dondia, *Atriplex* *sordida* Leconte
 Less densely pubescent; elytral punctuation distinctly
 visible; apex of aedeagus as seen from above narrow
 and gradually tapering to a point..... 4
- 4 Elytra usually darkly marked with transverse dark areas
 at base, at middle and near apex at the suture; apex
 pale; aedeagus rather short and stout with a fine,
 narrow tip; Ariz. to Calif. *apicalis* Blake
 Elytra usually without suture distinctly darkened;
 aedeagus long, slender, and tapering; Ariz. to Utah
 to Calif.; on *Chenopodium* *brisleyi* Blake
- 5 Aedeagus long and slender, with a dorsoventrally flattened
 apex 6

- Aedeagus shorter and robust and not with a dorso-ventrally flattened apex 10
- 6 Size large, 4-5.3 mm. long 7
 Smaller, 2-4 mm. long 8
- 7 Pronotum with prominent hind angles; N. Dak. to B.C. to Calif.; on sugar beet (*Beta*), *Chenopodium angularis* (Leconte)
 Pronotum without prominent hind angles; Fla. to Tex.; on *Batis* *batisia* Blatchley
- 8 Narrowly oblong, slender; prothorax with lateral margins angulate at middle; disc uneven with lateral and median depressions; Ariz. *minuta* Blake
 More broadly oblong; prothorax with lateral margins arcuate and disc more smoothly convex, with only slight depressions 9
- 9 Aedeagus unusually long; elytra finely and shallowly punctate; Tex.; on *Chenopodium* *obesula* Blake
 Aedeagus not unusually long; elytra rather coarsely and distinctly punctate; Colo. to Idaho; on sugar beet (*Beta*), *Chenopodium* *pallida* Blake
- 10 Aedeagus very broadly rounded, almost truncate at apex when viewed from above; 3.4-4.5 mm. long; Colo. to N. Mex. to Oreg.; on *Atriplex*, *Chenopodium*, sugar beet (*Beta*), kafircorn *elegans* Blake
 Aedeagus more or less tapering, sometimes acute at apex when viewed from above 11
- 11 Medium sized, 3-4 mm. long; with rather scant, short pubescence or with fine, silken pubescence; not deeply punctate 12
 Larger, 3.5-5 mm. long; conspicuously pubescent and coarsely punctate 13
- 12 Elytra without long intrahumeral sulcus, with scant short pubescence and finely punctate, somewhat shining; Tex. to Calif. to Alta.; on *Gutierrezia*, *Lepidium puberula* Blake
 Elytra sometimes with a long intrahumeral sulcus; either covered with a fine, silken pubescence or not shining but distinctly punctate; Tex. to Wyo. to Calif.; on *Chrysothamnus* *conspua* (Leconte)
- 13 Elytra with a long intrahumeral sulcus; pubescence long and not closely appressed but erect; Calif.; on *Artemisia* *guttulata* (Leconte)

- Elytra with only a short intrahumeral sulcus; pubescence closely appressed 14
- 14 Elytra shallowly and very densely punctate; aedeagus viewed from above rather abruptly contracted into a somewhat blunt, wedge-shaped apex; Kans. to Alta. to N. Mex.; on *Grindelia*.....*inornata* Blake
- Elytra deeply and more coarsely punctate; aedeagus usually longer and gradually narrowed at apex.... 15
- 15 Pronotum little depressed; the width considerably less than twice the length; elytral punctation markedly coarse and distinct; Alta. to Kans. to Ariz.....*debilis* Leconte
- Pronotum wider and more depressed on the sides; dense, grayish elytral pubescence somewhat obscures the coarse punctation; aedeagus long and heavy; Mont. to Idaho to Alta.; on *Artemisia*, *Solidago grisea* Blake

GENUS MIRACES JACOBY

Horn, 1893, described *Halticidea* as follows: "Head oval, not deeply inserted, the eyes oval, prominent and free, frontal tubercles distinct, not prominent; a transverse groove between the eyes; labrum transverse, faintly emarginate; maxillary palpi short and stout, the terminal joint conical, longer than the preceding joint. Antennae slender, nearly half the length of the body; first joint slightly clavate, twice as long as the second, this a third shorter than the third joint, fourth joint scarcely longer than third, joints five to ten slightly shorter, eleventh longer and acute at tip. Thorax more than twice as wide as long, sides arcuate, hind angles not distinct, disc convex, with a median transverse impression, sometimes indistinct or obliterated at middle; elytra oval, slightly oblong, the epipleurae distinct in front, but becoming internal behind the middle; anterior coxal cavities narrowly closed behind, the prosternum not visible between the coxae. Legs moderate in length, the tibiae scarcely broader at tip, the outer edge finely grooved, no terminal spurs; tarsi rather stout, the first joint about equal to the next two; claws strong, deeply bifid, the portions widely divergent. Body glabrous."

The anterior coxal cavities are open, not closed as described by Horn. The last ventral segment of the male is broadly emarginate, without a depression in front of the emargination.

Horn described the genus *Halticidea* to contain the three species, *placida*, *modesta*, and *delata*, which he also described as new. *H. delata* Horn is hereby designated as the type species of *Halticidea*.

Jacoby described *Miraces* in 1888 for the single Mexican species, *aeneipennis*. Examination of cotypes of *aeneipennis* shows that the tarsal claws of this species are bifid (not appendiculate as Jacoby stated) and that the species is identical with *Halticidea delata*. Consequently, *Halticidea* Horn must be suppressed as a synonym of *Miraces* Jacoby, and its species placed under the latter name. *M. delata* Horn is a synonym of *M. aeneipennis* Jacoby.

In addition to the species catalogued below, the following Caribbean species belong in *Miraces*: *Halticidea barberi* Blake, *H. dichroa* (Suffrian), and *H. glaber* (Blake). There is also an undescribed, pale species from Mexico.

There is no doubt that this genus belongs in the Galerucini, but its relationships with other genera are not very evident. It is probably rather closely related to *Dicoelotrachelus* Blake, but differs from that group in having glabrous elytra.

Miraces Jacoby

Miraces Jacoby, 1888, Biol. Centr.-Amer., Coleop. 6(1) :611. Type: *Miraces aeneipennis* Jacoby 1888, by monotypy.

Halticidea Horn, 1893, Trans. American Ent. Soc. 20:61. Type: *Halticidea delata* Horn, 1893, by present designation. New synonymy.

aeneipennis Jacoby Tex., Ariz., Guatemala

Miraces aeneipennis Jacoby, 1888, Biol. Centr.-Amer., Coleop. 6(1) :611, fig.

Halticidea delata Horn, 1893, Trans. American Ent. Soc. 20:63. New synonymy.

modesta (Horn) Fla.

Halticidea modesta Horn, 1893, Trans. American Ent. Soc. 20:62.

placida (Horn) Ariz.

Halticidea placida Horn, 1893, Trans. American Ent. Soc. 20:62.

Key to the North American species of *Miraces* Jacoby

- | | | |
|---|---|---|
| 1 | Elytra metallic blue or green; head and pronotum smooth; punctation scarcely evident | 2 |
| | Elytra black with faint bronze or aeneous luster; head and pronotum very distinctly punctate, the former alutaceous; punctation of elytra fine and not well impressed; apex of aedeagus narrowed, very small emargination at tip; 2.7-3 mm. long; Tex., Ariz., Guatemala; (figures 5, 15) | |
| | <i>aeneipennis</i> Jacoby | |

- 2 Base of pronotum regularly arcuate, hind angle not distinct; punctation of elytra rather fine and moderately closely placed. Apex of aedeagus not narrowed, bifid; 3-4.2 mm. long; Ariz. *placida* (Horn)
Base of pronotum truncate at middle, oblique on each side; hind angles of pronotum distinct; punctation of elytra coarse; 2.5 mm. long; Fla. *modesta* (Horn)

GENUS GALERUCA MULLER

Ovate, deep brown to piceous with pale yellow-brown elytral margin, densely and rather coarsely punctate; the head and sometimes the prothorax very inconspicuously pubescent; elytra with the suture raised and on each elytron three or four costae, sometimes with intermediate costae between the main ones.

Head coarsely and densely punctate, sparsely pubescent; a median depressed line running from occiput to lower end of front, dividing the frontal tubercles; front short, ending a little below antennal sockets; frontal tubercles prominently raised with a little depression on the vertex above them; eyes rather small, elliptical, widely separated. Antennae extend a little below the humeri, rather stout; first six or seven segments less pubescent than the last four or five; third segment 1.5 times the length of second and longer than fourth; fourth longer than fifth. Prothorax over twice as broad as long, narrowed anteriorly, sides angulate in many specimens, often with a slight constriction at middle or a little below, the margin more widely explanate in anterior half and turned upwards on the edge. Surface moderately shiny, very densely and coarsely punctate and irregular, more or less canaliculate in middle and with depressions on each side; a very short and sparse pubescence in some specimens. Elytra each with three to eight costae besides the sutural edges. Punctation very dense, and rather regular. Body beneath piceous, shining, lightly covered with pale pubescence. Last ventral abdominal segment of male broadly emarginate, with a distinct median apical depression; that of female evenly rounded or slightly truncate at apex. Prosternum not extending between coxae; anterior coxal cavities closed by the contiguous epimera. Middle tibiae of both male and female with a short spur at tip. Claws bifid, inner tooth short. Aedeagus nearly symmetrical, with basal spurs.

Length 6.5 to 12 mm.

The American species are very similar to each other and to those of Europe and Asia. Mrs. Blake's excellent paper gives good descriptions and figures of the North American species.

Galeruca Muller

Galeruca Geoffroy, 1762, Hist. Ins. 1:251.

Invalid because Geoffroy did not use binary nomenclature.

Galeruca Muller, 1764, Fauna Ins. Fridr., p. 14. Type:

Chrysomela tanacetii Linnaeus, 1758, designated by Latreille, 1810, Consid. Generales, p. 432.

Adimonia Laicharting, 1781, Verz. Tyrol. Ins., p. 190.

Galleruca Dejean, 1837, Cat. Coleop., ed. 3, p. 401.

Blake, 1945, Proc. Ent. Soc. Washington 47:53-63.

browni Blake

Manit., Alta.

Galeruca browni Blake, 1945, Proc. Ent. Soc. Washington 47:60, fig.

Galeruca externa: Criddle, 1913, 43rd Ann. Rept. Ent. Soc. Ontario (1912), p. 99.—Durstan, 1932, Canadian Dept. Agric., Ent. Bull. 32, p. 48.—Gibson, 1934, Canadian Dept. Agric., Ent. Bull. (n. ser.) 99, p. 34.

costatissima Blake

Utah, Colo., Ariz., N. Mex.

Galeruca costatissima Blake, 1945, Proc. Ent. Soc. Washington 47:61, fig.

externa Say

N.Y., Ont., Kans., Nebr.

Galleruca externa Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:858.

Adimonia externa (Say), Leconte, 1859, Complete Writings T. Say 2:222.

Galeruca externa Say, Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:214.—Horn, 1893, Trans. American Ent. Soc. 20:128.—Blake, 1945, Proc. Ent. Soc. Washington 47:55, fig.

Galeruca pomonae: Knab, 1905, Ent. News 16:230 (not *G. pomoni* Scop.).

popenoei Blake

Tex., N. Mex.

Galeruca popenoei Blake, 1945, Proc. Ent. Soc. Washington 47:61, fig.

rudis Leconte

N. Mex., Mont., B.C., Calif.

Galleruca rudis Leconte, 1857, preprint of 1860, Reports Expl. and Surv. for Railroad from Mississippi R. to Pacific Ocean, vol. 9, pt. 3, no. 1, p. 69.

Galeruca rudis Leconte, Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:214 (synonym of *G. externa*).—Blake, 1945, Proc. Ent. Soc. Washington 47:58, fig. (valid species).

Key to the species of *Galeruca* Muller

(Modified from Blake 1945)

- 1 Deep reddish or blackish brown with an indistinct pale elytral margin; elytral punctation very coarse and deep with many irregular, short, sharp ridges between the costae; 8 mm. long; N.Y. to Ont. to Nebr. to Kans.; on *Phlox* *externa* Say
 Very dark brown or piceous with distinct pale elytral margins; elytral punctation not so coarse, and the intercostal areas not broken up conspicuously by many sharply cut ridges 2
- 2 Between the usual 3 or 4 costae on each elytron are narrower and less elevated intermediate costae, making 7 or 8 costae on each elytron, the main costae very prominent; 9-12 mm. long; Utah to Colo. to Ariz. to N. Mex. *costatissima* Blake
 Usually only 3 or 4 distinct costae on each elytron, although ridges or remnants of intercostae present in many specimens 3
- 3 Costae not very elevated; punctation coarse, shallow, regular, and contiguous, and usually with little ridging between; 5.6-10 mm. long; Tex. to N. Mex. (figure 10) *popenoei* Blake
 Costae more or less sharply prominent; punctation more irregular, sometimes less dense, sometimes finer, often with small intercostal ridgings. 4
- 4 Punctuation on elytra not so dense; aedeagus with a somewhat attenuated tip (figure 14); 6.5-8 mm. long; N. Mex. to Mont. to B.C. to Calif.; on lupine
rudis Leconte
 Punctuation on elytra dense, contiguous; aedeagus with a slightly less attenuated tip; 8-10.5 mm. long; Iowa to Manit. to Alta.; on Cruciferae *browni* Blake

TRIBE METACYCLINI

In the American fauna the Metacyclini seem to be abundantly distinct from all other groups. The large, basal, aedeagal spurs and the truncate, flattened abdominal apex will quickly identify any male of this group. Some confusion might occur in examination of *Miraces*, which does have the distinct basal aedeagal spurs, although they are small. The apical, semi-circular depressed area of the abdominal apex

is rather weakly indicated in comparison with other Galerucini, but these small galerucines are rather distinct from the Metacyclini in other characters. Real trouble may be encountered in defining the Metacyclini and Galerucini in the Old World, particularly in Africa. Several genera (e.g., *Palaeophylia*) are so nearly intermediate between Metacyclini and Galerucini that placement in either of these groups is arbitrary. The intermediates cast a little doubt on the validity of the separation of the two groups. Possibly larval characters can give a better clue; however, no metacycline larva has ever been recognized or reported.

GENUS MALACORHINUS JACOBY

Body elongate to oval; pronotum much narrower than the elytra, usually narrowest at base. In some species the elytra are angularly produced at middle or are provided with marginal or submarginal tubercles or depressions or both. Antennae usually normal, but may be variously modified; shorter than length of body; in male and female, antennite 3 is one and one-half to two times the length of 2; 4 is shorter than 2 and 3 together but longer than 3. Head usually normal, but in *basalis* the vertex is excavated and the front is transversely produced. Maxillary palps with swollen apical segments. Width of pronotum is 1.3 to 1.45 times length; surface with or without a depression on each side of middle. Elytral punctation confused; surface feebly to moderately convex. Front coxal cavities open; prosternum may or may not separate front coxae. Abdomen usually normal, but one unnamed species from South America has a distinct median apical tubercles on abdominal sternite 4. Male with apex of fifth abdominal segment truncate, somewhat depressed at apex. Apex of female abdomen evenly rounded. First segment of hind tarsus in male about as long as following two segments together. Apical spurs present on all tibiae of male and female. Aedeagus with basal spurs; apex usually more or less pointed and symmetrical; orifice covered by a long, flat, sclerotized, asymmetrical plate; internal sac asymmetrical with sclerotized flagellum, two asperate lobes and one longer, smooth one. Length 3 to 8.5 mm. Each species is pale with dark markings. The pale areas may be testaceous, yellow, or red. The dark markings are black, dark brown, or reddish brown. Species of this genus are found from Arizona and Texas south to Venezuela and Brazil.

The species in which the elytra are modified in the male are easily identified by that character. Others may be confused with *Exora* Chevrolat which is separated from *Malacorhinus* by its wider pro-

thorax (width at least 1.5 times length). Three species are found in the United States. Males may be identified by the basal aedeagal spurs; asymmetrical orifice of the aedeagus; and the truncate, flattened apex of the abdomen. Females are rather difficult to key to genus, although they are quite distinctive, in our fauna, in their color patterns.

Malacorhinus Jacoby

Malacorhinus Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1): 582. Type: *Diabrotica foveipennis* Jacoby, 1879, by original designation.—Wilcox, 1951, Ohio Jour. Sci. 51:90.

acaciae (Schaeffer) Tex.

Cneorane ? acaciae Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, p. 246.

Malacorhinus acaciae (Schaeffer), Wilcox, 1951, Ohio Jour. Sci. 51:92, fig.

knollorum Wilcox Calif., Ariz.

Malacorhinus knollorum Wilcox, 1951, Ohio Jour. Sci. 51:92, fig.

tripunctatus (Jacoby) Guatemala, Tex.

Diabrotica tripunctata Jacoby, 1879, Proc. Zool. Soc. London 1879, p. 790.

Malacorhinus tripunctatus (Jacoby), Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):583, fig.—Greene, 1916, Ent. News 27:44.

Key to the species of *Malacorhinus* Jacoby

- 1 Large, 8.5 mm. long; head, pronotum, and elytra pale; each elytron with a small black spot near suture at basal third, another at apical third, and another near lateral margin at middle; male with elytra broadly angulate at middle; lateral dark spot in male in a deep depression containing a small tubercle; Tex. to Guatemala (figures 45, 46).....*tripunctatus* (Jacoby)
- Smaller, 4-6 mm. long; elytra vittate or each with two large dark spots, one basal and one apical 2
- 2 Elytra each with a basal and an apical black spot, may be joined; surface finely punctulate; 4-5 mm. long; Tex.; on *Acacia**acaciae* (Schaeffer)
- Elytra each with two longitudinal stripes which may be joined at the ends and middle; surface moderately punctate; 4-6 mm. long; Ariz. to Calif..*knollorum* Wilcox

MALACORHINUS KNULLORUM WILCOX

A rather serious error was committed in the illustration of the aedeagus of *Malacorhinus knullorum* Wilcox accompanying the original description (Ohio Jour. Sci., 51:92). The orificial plate is asymmetrical, the left side being free from the rest of the organ for a much greater distance than the right side. This may not seem to be very important, but such a character appears to be useful in defining genera in this tribe.

TRIBE LUPERINI

The Luperini may best be identified by the fact that their larvae feed on roots below the surface of the ground. These rootworms are long, slender, very sparsely hairy, white larvae (figure 151). Adults may be recognized by two or three characters found on the male. Females will be much more difficult to identify, and in some cases specimens must be keyed to genus or species before tribal recognition will be possible.

The aedeagus in the Luperini never have the prominent basal spurs which are so typical of Galerucini and Metacyclini. In the Sermlyni, which also lack spurs, the basal foramen of the aedeagus is very broadly rounded, almost circular in outline. Most genera of Luperini have a rectangular, apical, median lobe on the last ventral abdominal segment of the male. They are generally small to medium sized, elongate, glabrous beetles with appendiculate tarsal claws, although there are exceptions to all of these characters.

The North American Luperini can be divided into three fairly satisfactory subtribes. The Diabroticina are strictly American in range. They can be defined on these male characters: No apical, ventral, abdominal lobe; apical spurs usually on middle and posterior tibiae only; aedeagus with very weakly sclerotized base and usually with a sclerotized plate over the apical orifice. In the Monoleptina the basal segment of the posterior tarsus is usually very long; the third antennal segment is short; and the male has an apical abdominal lobe which is as long or longer than wide. The Luperina are much more varied in form. The apical abdominal lobe is rectangular but much wider than long. In *Scelolyperus* and *Pseudoluperus* the abdominal lobe is sometimes extremely short or even absent.

SUBTRIBE DIABROTICINA

This subtribe is fairly easily defined by male characters. The last ventral abdominal segment is slightly truncate at apex, may be very

slightly depressed, without any indication of an apical lobe. The margins of the basal foramen of the aedeagus are thin, not produced to form either tubercles or basal spurs. Males have apical spurs on middle and posterior tibiae, none on the front. Females have apical spurs on all tibiae.

In general, these insects are elongate or elongate oval, with the prothorax distinctly narrower than the elytra. *Paranapiacaba peregrina* (Jacoby) has a sparse coating of erect hairs on the elytra but other species are glabrous. The antennae are normal, filiform except in males of *Paratriarius*, *Phyllethris* and *Cerotoma*. The species with bifid claws are placed in the Diabroticites, those with appendiculate claws and normal middle tibiae in male in the Cerotomites, and those with appendiculate claws and notched middle tibiae in male in the Phyllethrites.

Larvae of all known species of this subtribe are rootworms. Species of *Diabrotica*, *Cerotoma*, and *Acalymma* often become serious pests of agricultural crops.

GENUS PARATRIARIUS SCHAEFFER

Figure 37

Body elongate oval; sides of elytra nearly straight in basal half; prothorax distinctly narrower than elytra. Prothorax with lateral marginal bead.

Head normal in males. Ocular sulcus distinct, narrow, deep. Interocular sulcus indistinct, even behind frontal tubercles. Tubercles fairly distinct but weakly delimited behind, moderately swollen, separated from orbit by a distinct groove. Longitudinal frontal carina narrow, not extending between tubercles. Antennae reach apical third of elytra; normal, filiform in female; modified in male with segments 5, 6, and 7 distinctly enlarged. Antennal segment 3 twice as long as 2; segment 4 as long as 3. Pronotal width nearly twice the length. Pronotum as wide at base as at apex; widest at apical third; sides weakly sinuate; lateral margins moderately explanate. Surface of pronotum moderately convex, with disc flattened; surface with a broad, shallow depression on each side of middle; glabrous. Elytra one-fourth wider than prothorax at base. Surface of elytra moderately convex, with faint indications of longitudinal carina extending back from humerus. Male elytra with a broad sutural depression at apical fifth, a weak tubercle at the lateral margin of the depression on each side. Elytra with punctation confused, surface glabrous.

Epipleura normal, gradually narrowed, distinct nearly to sutural angles. Prosternum not extending between front coxae. Front coxal

cavities open. Legs normal; male with apical spurs on middle and hind tibiae but none on front; female with apical spurs on all tibiae. Basal tarsal segment of hind leg of male longer than segments 2 and 3 together but not so long as all of the following segments together. Tarsal claws bifid. Male with last ventral abdominal segment truncate or slightly emarginate, without apical lobe, nearly as in female. Aedeagus with apex truncate; orifice not covered by a sclerotized plate; base without spurs.

A single species, *P. dorsatus* (Say), of this neotropical genus is known from the lower Mississippi and Ohio River valleys. Both male and female can be recognized in North American fauna by the dark metallic blue or blue-green elytra. The males are unusual in the modified antennal segments and the depression near the apex of the elytra.

Paratriarius Schaeffer

Paratriarius Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci.

Bull. 1:243. Type: *Galleruca dorsata* Say, 1824, by monotypy.

dorsatus (Say) Ohio, Ark.

Galleruca dorsata Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:456.—Horn, 1893, Trans. American Ent. Soc. 20:132.

Diabrotica dorsata (Say), Dury, 1904, Ent. News 15:53.

Neobrotica dorsata (Say), Dury, 1906, Jour. Cincinnati Soc. Nat. Hist. 20:253.

Paratriarius dorsata (Say), Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1:243.—Wilcox, 1954, Ohio Biol. Survey, Bull. 43 (vol. 8, no. 3), p. 424, fig.—Barber, 1947, Proc. Ent. Soc. Washington 49:160 (fig. of aedeagus).

GENUS DIABROTICA CHEVROLAT

Body elongate oval; sides of elytra nearly straight in basal half in male, may be curved in female. Prothorax narrower than elytra, with distinct lateral marginal bead. Antennae slender. Color variable, but North American species without metallic luster.

Head not modified, short; genae shorter than long diameter of eye. Frontal tubercles distinct but poorly delimited. Prothorax with or without discal depressions. Elytra normal, may have more or less distinct carinae. Elytral punctation confused even when the elytra are carinate. Legs not modified. Male with apical spurs on middle and posterior tibiae, none on front. Female with spurs on all tibiae. Prosternum not produced between the coxae. Front coxal cavities open. Claws bifid.

Male with last ventral abdominal segment slightly truncate, without apical lobe, nearly as in female. Aedeagus symmetrical, without basal spurs; orifice covered by a large sclerotized plate; ventral surface with a broad, longitudinal groove which is narrowed near apex by a pair of triangular lobes attached to the sides.

In *Diabrotica* subgenus *Diabrotica*, the antennal segments 2 and 3 are small, equal in length or segment 3 very little longer. Segment 4 is longer than 2 and 3 together.

Diabrotica Chevrolat

Diabrotica Chevrolat, 1837, in Dejean, Cat. Coleop., ed. 3, p. 404.

Type: *Crioceris fucata* Fabricius, 1787; designated by Barber, 1947, Proc. Ent. Soc. Washington 49:151.

Subgenus Diabrotica Chevrolat

atripennis (Say)

Manit., Mass., Tex., Dak.

Galleruca atripennis Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:461.

Phyllobrotica atripennis (Say), Leconte, 1859, Complete Writings T. Say 2:224.

Diabrotica atripennis (Say), Horn, 1893, Trans. American Ent. Soc. 20:90, 95.

Galleruca (Adimonia) cristata Harris, 1837, Trans. Nat. Hist. Soc. Hartford 1:90, fig. (This article reprinted, 1918, Trans. American Ent. Soc. 44:260.).

Diabrotica atripennis var. *crestata* (Harris), Horn, 1893, Trans. American Ent. Soc. 20:95.

Diabrotica atripennis ab. *cristata* (Harris), Weise, 1924, Coleop. Cat., pars 78, p. 27.

Diabrotica fossata Leconte, 1858, Proc. Acad. Nat. Sci. Philadelphia 9:88.

Diabrotica atripennis var. *fossata* Leconte, Horn, 1893, Trans. American Ent. Soc., 20:95.

Diabrotica atripennis ab. *fossata* Leconte, Weise, 1924, Coleop. Cat., pars 78, p. 27.

balteata Leconte

Ga., Fla., Calif.

Diabrotica balteata Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 213.—Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):530, fig.—Horn, 1893, Trans. American Ent. Soc. 20:90, 93.—Chittenden, 1910, U.S. Dept. Agric., Bur. Ent., Bull. 82, pt. 6, p. 69, 76, fig. (biol.).—Sell, 1918, Ent. News 29:93 (biol.).—

- Bechyné, 1956, Ent. Arb. Mus. Frey 7:344 (r. Venez. Colombia).
 —Bechyné, 1958, Ent. Arb. Mus. Frey 9:546 (r. Guatemala).
Diabrotica sallei Baly, 1886, Jour. Linn. Soc., Zool. 19:227.—
 Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):530 (synonym of
balteata Leconte).
- lemniscata Leconte N. Mex.
Diabrotica lemniscata Leconte, 1868, Trans. American Ent. Soc.
 2:58.—Horn, 1893, Trans. American Ent. Soc. 20:90,95.
- longicornis (Say) Conn., Wis., Tex.
Galleruca longicornis Say, 1824, Jour. Acad. Nat. Sci. Philadelphia
 3:460
Phyllobrotica longicornis (Say), Leconte, 1859, Complete Writ-
 ings T. Say 2:223.
Diabrotica longicornis (Say), Leconte, 1865, Proc. Acad. Nat. Sci.
 Philadelphia, 1865, p. 213.—Horn, 1893, Trans. American Ent.
 Soc. 20:90,94.—Blatchley, 1910, Coleop. Indiana, p. 1172.—Gar-
 man, 1907, Kentucky Agric. Exp. Sta., Bull. 130, p. 45.
- picticornis Horn Tex.
Diabrotica picticornis Horn, 1893, Trans. American Ent. Soc.
 20:90-91, fig.—Chittenden, 1910, U.S. Dept. Agric., Bur. Ent.,
 Bull. 82, pt. 6, p. 68, 76, fig.
- undecimpunctata Mannerheim Wash., Calif.
Diabrotica undecimpunctata Mannerheim, 1843, Bull. Soc. Imp.
 Nat. Moscou 16(2):310.
Diabrotica undecimpunctata subsp. *undecimpunctata* Mannerheim,
 Barber, 1947, Proc. Ent. Soc. Washington 49:153.
Diabrotica soror Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia,
 1865, p. 212.—Horn, 1893, Trans. American Ent. Soc. 20:90,93.
 —Kellogg, 1906, Science 24:621, fig.—Chittenden, 1910, U.S.
 Dept. Agric., Bur. Ent., Bull. 82, pt. 6, p. 71, fig.—Sell, 1915,
 Jour. Econ. Ent. 8:515.—Barber, 1947, Proc. Ent. Soc. Wash-
 ington 49:153 (synonym of *undecimpunctata undecimpunctata*
 Mannerheim).
- undecimpunctata howardi Barber Maine, Fla., Colo., Ariz.
Diabrotica undecimpunctata subsp. *howardi* Barber, 1947, Proc.
 Ent. Soc. Washington 49:153, fig. (new name for *Chrysomela*
duodecimpunctata Fabricius, 1775, not Linnaeus, 1758).
Chrysomela duodecimpunctata Fabricius, 1775, Syst. Ent., p. 103.
 —Fabricius, 1781, Spec. Ins. 1:128.—Fabricius, 1787, Mant. Ins.
 1:74.—Gmelin, 1790, Linne Syst. Nat. 1(4):1669.
Galleruca duodecimpunctata (Fabricius), Fabricius, 1792, Ent.
 Syst. 2:15.

Crioceris duodecimpunctata (Fabricius), Fabricius, 1801, Syst. Eleuth. 1:457.

Galeruca duodecimpunctata (Fabricius), Olivier, 1808, Ent. 6:628, fig.

Diabrotica duodecimpunctata (Fabricius), Dejean, 1837, Cat. Coleop., ed. 3, p. 405.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 220.—Horn, 1893, Trans. American Ent. Soc. 20:90,92.—Blatchley, 1910, Coleop. Indiana, p. 1172.—Sweetman, 1926, Jour. Econ. Ent. 19:484-490, fig. (biol.).—Isely, 1929, Arkansas Agric. Exp. Sta., Bull. 232, 31 pp., fig. (biol.).—Arant, 1929, Alabama Agric. Exp. Sta., Bull. 230, pp. 1-46, fig. (biol.).—Smith & Allen, 1932, Jour. Econ. Ent. 25:53-57 (biol.).—Balduf, 1942, Ent. News 53:171, fig. (biol.).

undecimpunctata tenella Leconte Utah, Ariz.

Diabrotica tenella Leconte, 1858, Proc. Acad. Nat. Sci. Philadelphia, 1858, p. 58.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 213.

Diabrotica duodecimpunctata var. *tenella* Leconte, Horn, 1893, Trans. American Ent. Soc. 20:92.

virgifera Leconte S. Dak., Tex., Ariz.

Diabrotica virgifera Leconte, 1858, Trans. American Ent. Soc. 2:59.—Horn, 1893, Trans. American Ent. Soc. 20:90,94.

Diabrotica filicornis Horn, 1893, Trans. American Ent. Soc. 20:90,94.

Key to the species of *Diabrotica* subgenus *Diabrotica* Chevrolat

- 1 Elytra at least partly pale, yellow or green..... 2
Elytra entirely dark; 5-6 mm. long; Mass. to Dak. to Tex. *atripennis* (Say)
- 2 Pronotum pale, yellow or green 3
Pronotum black; elytra black with lateral margin and median longitudinal stripe pale; 5-6 mm. long; N. Mex. *lemniscata* Leconte
- 3 Elytra with distinct black or dark brown markings..... 4
Elytra without black or dark brown markings..... 5
- 4 Each elytron with a longitudinal stripe running from humerus; 5-6 mm. long; S. Dak. to Tex. to Ariz.
virgifera Leconte
Elytral dark markings are round spots or transverse bands, not longitudinal stripes 8
- 5 Elytra with longitudinal carinae 6
Elytra not carinate; tibiae usually dark; elytra green,

each with five yellow spots (figure 32), rarely entirely yellow; 5-6 mm. long; Ga. to Fla. to Calif.

balteata Leconte

- 6 Each elytron with four or five indistinct carinae on disc between suture and the prominent carina arising at humerus; color usually green 7
- Each elytron with only two carinae, both arising at humerus; elytra usually black; head pale or with black spots; pronotum black or pale; 5-6 mm. long; Mass. to Dak. to Tex. *atripennis* (Say)
- 7 Head black *virgifera* Leconte
- Head pale, green, yellow, or reddish brown; 4.5-5 mm. long; Conn. to Wis. to Tex. *longicornis* (Say)
- 8 Elytra with a broad, basal, black band enclosing on each side an oval pale spot; also with a narrow, arcuate transverse band at apical third; antennal segments 9 and 10 conspicuously paler; 6.5 mm. long; Tex.
- picticornis* Horn
- Elytra with three transverse rows of spots. 9
- 9 Legs and abdomen entirely black; Pacific coast
- undecimpunctata undecimpunctata* Mannerheim
- Legs and abdomen more or less pale. 10
- 10 Spots black and rather large; form robust; eastern United States *undecimpunctata howardi* Barber
- Spots smaller and brownish; form less robust; Ariz. to Utah *undecimpunctata tenella* Leconte

SUBGENUS PARANAPIACABA BECHYNÉ, NEW STATUS

Elongate oval; sides of elytra nearly straight in basal half in male, may be curved in female. Prothorax narrower than elytra, with distinct lateral marginal bead. Antennae slender; segment 2 small; segment 3 at least twice as long as 2, nearly as long as 4. Elytra with confused punctuation, without distinct carinae. Colored with black, brown, yellow, and/or testaceous. Head not modified; frontal tubercles distinct but poorly delimited. Mandibles with teeth 2 and 3 normal; tooth 1 is very small.

Prothorax with or without discal depressions. Elytra normal, evenly convex. Legs not modified. Male with apical spurs on middle and posterior tibiae, none on front. Female with spurs on all tibiae. First segment of posterior tarsus long, in male longer than the two following segments but not so long as all the following segments

together. Claws bifid. Prosternum not produced between the coxae. Front coxal cavities open.

Male with last ventral abdominal segment slightly truncate at apex, without apical lobe. Aedeagus symmetrical, without basal spurs; orifice covered with a sclerotized plate; ventral surface with a broad, longitudinal sulcus which is narrowed near apex by a pair of triangular lobes attached to the sides.

Paranapiacaba is very close to typical *Diabrotica*, differing only in the longer third antennal segment. Although it was originally described as a full genus, it is here listed as a subgenus of *Diabrotica*.

Bechyné described *Paranapiacaba* for those insects previously placed in *Diabrotica* Chevrolat which have the third antennal segment distinctly longer than the second; elytral punctuation confused; genae short; and legs, head, and antennae not otherwise modified. Bechyné placed *D. tricineta* (Say) in *Paranapiacaba*. *D. connexa* Leconte must also be transferred to this group. *D. peregrina* Jacoby and the Mexican *D. hirsuta* Jacoby would key out to *Paranapiacaba* and may best be placed here for the present. However, they are not typical and seem to be more closely related by genitalic characters to *Acalymma*.

Subgenus *Paranapiacaba* Bechyné

Paranapiacaba Bechyné, 1958, Ent. Arb. Mus. Frey 9:563. Type:

Diabrotica decemverrucata Gahan, 1891, by original designation.
connexa Leconte Tex., Mexico

Diabrotica connexa Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 212.—Jacoby, 1887, Biol. Centr.-Amer., Coleop., 6(1):549, fig.—Horn, 1893, Trans. American Ent. Soc. 20:90-91, fig.—Chittenden, 1910, U.S. Dept. Agric., Bur. Ent., Bull. 82, pt. 6, p. 68, fig.

tricincta (Say) Kans., Colo., Mexico

Galleruca tricineta Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:457.

Diabrotica tricineta (Say), Leconte, 1859, Complete Writings T. Say 2:221.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 212.—Jacoby, 1892, Biol. Centr.-Amer., Coleop. 6(1, suppl.):331.—Horn, 1893, Trans. American Ent. Soc. 20:92.

Paranapiacaba tricineta (Say), Bechyné, 1958, Ent. Arb. Mus. Frey 9:562.

Diabrotica suffriani Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):551, fig.—Jacoby, 1892, Biol. Centr.-Amer., Coleop. 6(1, suppl.):331 (synonym of *tricincta* Say).

peregrina Jacoby

Tex., Mexico

Diabrotica peregrina Jacoby, 1892, Biol. Centr.-Amer., Coleop. 6(1, suppl.):330, fig.—Schaeffer, 1905, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1(7):171.

Key to the species of *Diabrotica* subgenus *Paranapiacaba* Bechyné

- 1 Pronotum dark; size small, 3.2-4 mm. long; elytra pale with two broad, irregular, transverse bands (figure 34); elytra distinctly pubescent with sparse, erect hairs; Tex. to Mexico *peregrina* Jacoby
- 2 Pronotum pale; larger 2
- 2 Elytra with three transverse black bands and a small apical spot; second and third bands divided by suture; 5.5-7 mm. long; Kans. to Colo. to Mexico.... *tricincta* Say
- Elytra with a broad, basal, brown band enclosing an oval pale spot on each side; also with four, small, round spots in an arcuate, transverse row across apical third; 5.5-7 mm. long; Tex. to Mexico
connexa Leconte

GENUS ACALYMMA BARBER

Elongate oval; sides of elytra nearly straight in basal half in male, may be curved in female. Prothorax narrower than elytra, with distinct lateral marginal bead. Antennae slender; segment 2 small; segment 3 at least twice as long as 2, nearly as long as 4. Elytra with punctation moderate to coarse, usually arranged in distinct rows, often with carinae between alternate rows of punctures. Elytra usually yellow with black stripes.

Head normal; frontal tubercles distinct but poorly delimited. Mandibles with teeth 1, 2, and 3 normal. Prothorax with a large, shallow depression on each side of middle; these depressions frequently confluent. Prosternum not produced between the coxae. Front coxal cavities open. Legs not modified. Male with apical spurs on middle and posterior tibiae, none on front. Female with spurs on all tibiae. Male with first segment of posterior tarsus longer than the following two segments together but not so long as all of the following segments. Claws bifid.

Male with last ventral abdominal segment slightly truncate at apex, without apical lobe. Aedeagus symmetrical, without basal spurs; orifice covered with a very narrow sclerotized plate; ventral surface without a median sulcus or, if a sulcus is present, it is not narrowed near apex by a pair of lobes as in *Diabrotica*.

The species of this genus are usually found on the Curcubitaceae, and some of them are serious pests of curcubit crops.

Acalymma Barber

Acalymma Barber, 1947, Proc. Ent. Soc. Washington 49:154.

Type: *Acalymma gouldi* Barber, 1947, by original designation.

blandula (Leconte) Kans., Tex., N. Mex.

Diabrotica blandula Leconte, 1868, Trans. American Ent. Soc. 2:58.—Horn, 1893, Trans. American Ent. Soc. 20:90, 96.

Acalymma blandula (Leconte), Bechyné, 1955, Bull. Inst. Roy. Sci. Nat. Belgique 31(5):8.—Barber, 1947, Proc. Ent. Soc. Washington 49:155, 161, fig.

Diabrotica nitida Linell, 1897, Proc. U.S. Nat. Mus. 20:483.—Barber, 1947, Proc. Ent. Soc. Washington 49:155 (synonym of *blandula* Leconte).

gouldi Barber N.Y., Que., Wis., Ind.

Acalymma gouldi Barber, 1947, Proc. Ent. Soc. Washington 49:154, fig.—Bechyné, 1955, Bull. Inst. Roy. Sci. Nat. Belgique 31(5):8.—Lammers, 1964: Ent. News 75:187-189 (biol.; on *Echinocystus lobata*).

trivittata (Mannerheim) Tex., Oreg., Calif.

Diabrotica trivittata Mannerheim, 1843, Bull. Soc. Imp. Nat. Moscou 16(2):309.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 213.—Horn, 1893, Trans. American Ent. Soc. 20:91, 97.—Chittenden, 1910, U.S. Dept. Agric., Bur. Ent., Bull. 82, pt. 6, p. 75.—Sell, 1916, Jour. Econ. Ent. 8:5191.

Acalymma trivittata (Mannerheim), Barber, 1947, Proc. Ent. Soc. Washington 49:157, fig.

vincta (Leconte) Ga., Fla.

Diabrotica vincta Leconte, 1878, Proc. American Philos. Soc. 17:416.—Horn, 1893, Trans. American Ent. Soc. 20:91, 96.

Acalymma vincta (Leconte), Barber, 1947, Proc. Ent. Soc. Washington 49:155, fig.—Bechyné, 1955, Bull. Inst. Roy. Sci. Nat. Belgique 31(5):8.

vittata (Fabricius) Eastern United States

Crioceris vittata Fabricius, 1775, Syst. Ent., p. 122.—Fabricius, 1781, Spec. Ins. 1:156.—Fabricius, 1787, Mant. Ins. 1:90.—Fabricius, 1792, Ent. Syst. 1(2):12.—Fabricius, 1801, Syst. Eleuth. 1:455.

Galeruca vittata (Fabricius), Olivier, 1808, Ent. 6:633, fig.

Diabrotica vittata (Fabricius), Dejean, 1837, Cat. Coleop., ed. 3, p. 405.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865,

- p. 213.—Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):535, fig.
 —Horn, 1893, Trans. American Ent. Soc. 20:91, 96.—Gahan,
 1893, Trans. Ent. Soc. London, 1893, p. 368, fig.—Blair, 1920,
 Ann. Nat. Hist., London 5:163.—Sweetman, 1925, Jour. Econ.
 Ent. 18:795 (biol.).—Houser & Balduf, 1925, Ohio Agric. Exp.
 Sta., Bull. 388, pp. 239-364, fig.—Jewett, 1927, Kentucky Agric.
 Exp. Sta., Circular 37, pp. 19-34, figs. (biol.).—Isely, 1927,
 Arkansas Agric. Exp. Sta., Bull. 216, pp. 1-36, figs. (biol.).—
 Haseman, 1931, Jour. Econ. Ent. 24:486-490 (biol.).
Acalymma vittata (Fabricius), Barber, 1947, Proc. Ent. Soc.
 Washington 49:155, fig.
Cryptocephalus (*Cistela*) *americana* Gmelin, 1790, Linne Syst.
 Nat. 1(4):1715 (replacement name for *Cistela melanocephala*
 Fabricius).
Cistela melanocephala Fabricius, 1775, Syst. Ent., p. 118.—Fabri-
 cius, 1792, Ent. Syst. 1(2):12 (synonym of *Crioceris vittata*
 Fabricius).

Key to the species of *Acalymma* Barber

- 1 Elytra vaguely subsulcate; the punctures irregular and
 separated by smooth lines 2
 Elytra regularly sulcate-striate; the intervals very
 regularly elevated; the punctures arranged quite
 regularly in double rows between the carinae..... 3
- 2 Tibiae carinate; mesosternum and metasternum and most
 of legs pale *blandula* (Leconte)
 Tibiae not carinate; mesosternum and metasternum
 and most of legs black *vincta* (Leconte)
- 3 Elytral carinae 2, 3, and 4 pale; abdomen black..... 4
 Elytral carinae 2 and 3 pale, 4 dark (figure 38); abdo-
 men pale; Que. to N.Y. to Ind. to Wis..... *gouldi* Barber
- 4 Aedeagus with apex sinuately elevated; tibiae at least partly
 pale; eastern United States *vittata* (Fabricius)
 Aedeagus with apex deflected; tibiae may be entirely
 black; Tex. to Oreg. to Calif. . . *trivittata* (Mannerheim)

GENUS AMPHELASMA BARBER

Elongate oval; sides of elytra curved; prothorax distinctly nar-
 rower than elytra. Prothorax with lateral marginal bead. Head nor-
 mal in male. Interocular distance about one-half width of head across
 eyes. Ocular sulcus distinct but shallow. Coronal suture broadly de-
 pressed near interocular sulcus. Interocular sulcus indistinct even

behind tubercles. Frontal tubercles fairly distinct but weakly delimited behind, moderately swollen, separated from orbit on each side by a broad depression. Longitudinal frontal carina narrow. Antennae not modified in male, reaching middle of elytra. Antennal segment 3 twice as long as 2; segment 4 is as long as 2 and 3 together. Pronotal width is 1.4 times the length. Pronotum as wide at base as at apex; moderately, evenly convex, with a small depression on each side at middle; surface glabrous. Elytra half again as wide as pronotum at base; moderately convex, without carinae; confusedly punctate; glabrous.

Epipleuron rather wide, flat, gradually narrowed, distinct to apical angle. Prosternum not extending between front coxae. Front coxal cavities open. Legs normal in male. Apical spurs on all tibiae in female, on only middle and hind tibiae of male. Basitarsus of hind leg about as long as segments 2 and 3 together. Claws bifid. Male with last ventral abdominal segment slightly truncate, without lobe or emargination, nearly as in female. Aedeagus without basal spurs; orifice not covered by a sclerotized plate. This genus contains one species from Arizona and several from Mexico and Central America. The small pronotal depressions and form of the aedeagus are distinctive. The elytra are vittate, but the punctures are not in rows as are those of *Acalymma*.

Amphelasma Barber

Amphelasma Barber, 1947, Proc. Ent. Soc. Washington 49:158.

Type: *Galleruca cava* Say, 1835, by original designation.

bipuncticollis (Schaeffer)

Ariz.

Diabrotica bipuncticollis Schaeffer, 1905, Brooklyn Inst. Arts. Sci. Mus., Sci. Bull. 1, no. 7, p. 171.

Amphelasma bipuncticollis (Schaeffer), Barber, 1947, Proc. Ent. Soc. Washington 49:158.

GENUS NEOBROTICA JACOBY

Elongate oval; sides of elytra nearly straight in basal half in male, may be curved in female. Colored yellow and/or black. Antennae reach beyond middle of elytra; slender, not modified in the United States species. Antennal segment 2 small; segment 3 a little longer than 2; 4 longer than 3 but not so long as 2 and 3 together. Head not modified. Frontal tubercles distinct but poorly delimited. Mandibles with teeth 1, 2, and 3 normal.

Prothorax narrower than elytra, with distinct lateral margins; surface with a deep, irregular, transverse depression. Elytra normal;

punctuation usually confused, but in some species the punctures are in more or less regular rows. Elytra may be evenly convex or carinate; glabrous but may have a few scattered, erect hairs on apical half. Epipleura narrow, becoming gradually narrower, distinct to apical angles.

Legs not modified. Male with apical spurs on middle and posterior tibiae, none on front. Female with apical spurs on all tibiae. First segment of posterior tarsus long; in male longer than the two following segments but not so long as all the following segments together. Claws appendiculate. Prosternum not produced between the coxae. Front coxal cavities open.

Aedeagus similar to that of *Diabrotica*: symmetrical, without basal spurs; orifice covered by a sclerotized plate; ventral surface with a broad longitudinal sulcus which is narrowed near apex by a pair of triangular lobes attached to the sides.

Neobrotica Jacoby

Neobrotica Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):571.

Type: *Neobrotica variabilis* Jacoby, 1887, designated by Weise, 1924, Coleop. Cat., pars 78, p. 103.

pluristicta Fall

Ariz.

Neobrotica pluristicta Fall, 1910, Trans. American Ent. Soc. 36: 148.

NEOBROTICA PLURISTICTA FALL

Figure 33

This is the only representative of the genus occurring in the United States. It is pale yellow; each elytron with six or seven small dark spots—one humeral, one subscutellar, one median lateral, one near middle of disc, one at apical third near median line of disc, one lateral at apical angle, and sometimes a very small one near the last. Antennae, tibiae, and tarsi dark. Elytra closely punctate striate. Length 5.3 to 6.7 mm.

Type. The type in the Fall collection (MCZ) is from Baboquivi Mountains, Arizona.

Other specimens examined. ARIZONA: 2, 2 mi. E. Ruby, August 14, 1954, F. G. Werner (U.ARIZ.).

GENUS METROBROTICA BECHYNÉ**Figures 36, 40, 41**

Elongate oval; sides of elytra nearly straight in basal half in male, strongly curved in female. Colored yellow and black. Antennae reach apical third of elytra; slender, not modified in male of *furcata* but with segments 3 and 4 modified in male of *geometrica*. Antennal segment 2 small; segment 3 is three and a half times length of 2; segment 4 slightly more than half as long as 3. Eyes small. Vertex unmodified. Interocular sulcus very faintly indicated; frontal tubercles indistinct. Front convex, without any trace of longitudinal carina; male with a hole in the middle of clypeus, surrounded by a funnel-shaped structure in *furcata*, within a transverse depression in *geometrica*. Mandibles with teeth 1, 2, and 3 normal.

Prothorax narrower than elytra; without lateral, marginal bead; surface with a broad, shallow, transverse, median depression. Elytra normal, glabrous, with confused punctation; epipleura narrow at base, gradually becoming narrower, recognizable to apical angles.

Front tibia thickened in male; basal segment of front tarsus somewhat enlarged. Male with apical spurs on middle and posterior tibiae, none on front. Female with apical spurs on all legs. First segment of hind tarsus long, longer than the two following segments but not so long as all of the following segments together. Tarsal claws appendiculate. Prosternum not produced between the coxae. Front coxal cavities open. Aedeagus similar to that of *Diabrotica*: symmetrical, without basal spurs; orifice covered by a sclerotized plate; ventral surface with a broad longitudinal sulcus which is narrowed near apex by a pair of triangular lobes attached to the sides. Length 4.5 to 6 mm.

The unmargined prothorax distinguishes this genus very easily. It is closely related to *Cerotoma* and *Gynandrobrotica*.

Metrobrotica Bechyné

Metrobrotica Bechyné, 1958, Ent. Arb. Mus. Frey 9:596. Type:

Cerotoma geometrica Erichson, 1847, by original designation.

furcata (Olivier)

Tex.

Galeruca furcata Olivier, 1808, Ent. 6:643, fig.

Cerotoma furcata (Olivier), Dejean, 1837, Cat. Coleop., ed. 3, p. 403.

Neobrotica furcata (Olivier), Schaeffer, 1906. Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, p. 245.

Metrobrotica furcata (Olivier), Bechyné, 1958, Ent. Arb. Mus. Frey 9:596.

METROBROTICA FURCATA (OLIVIER)**Figure 36**

Head and prothorax yellow; elytra with lateral margins, base, and suture to apical fifth pale, sutural stripe in apical fifth turning obliquely away from suture, disc black; male with third segment very long, but antennae not otherwise modified; male with a small hole in middle of frons. Length 4.4 to 5.7 mm.

Type. Olivier recorded this species merely from North America. His figure is quite satisfactory.

Specimens examined. TEXAS: 1 ♂, 1 ♀, Brownsville (W).

This species is quite similar to the species of *Cerotoma* in general form. It differs in coloration, lack of pronotal margins, and the modified head in the male. It has been recorded only from the Brownsville, Texas, area.

GENUS CEROTOMA CHEVROLAT

Oval or elongate oval; prothorax distinctly narrower than elytra. Head rather long, modified in males of some species; front broad, flat, without distinct longitudinal carina. Interocular sulcus indicated only at middle. Tubercles swollen, transverse, but not distinctly delimited behind or at sides. Supratentoria distinct, very close to margin of eye. Antennae short reaching to middle or basal third of elytra; segment 3 at least three times length of 2, longer than 4.

Pronotum distinctly margined, a little wider than long, rather strongly convex at sides, flattened on disc; surface very slightly impressed each side of middle. Elytra evenly, moderately convex; punctures confused or with slight tendency to form longitudinal rows.

Epipleura moderately wide at base, becoming a little wider behind humerus, then gradually narrower, becoming indistinct at apical angles. Legs normal; apical spurs on all tibiae of female; on middle and hind but not on front tibiae of male. Segment 1 of hind tarsus longer than 2 and 3 together but not so long as 2, 3, and last together. Tarsal claws appendiculate. Mandibles with five large, evenly spaced teeth. Prosternum not extending between coxae. Front coxal cavities closed by the contiguous epimera. Last ventral abdominal segment of female evenly rounded.

Male. Antennae similar to those of female in some species; in others segment 3 is very wide, incised at apex leaving an acute apical spine, segment 4 produced laterally to form a transverse triangle which is acute at apex. Head in some species unmodified; in other species the frons is very deeply, transversely excavated; basal margin

of excavation produced into a thin lamella which extends over the excavation; apical and lateral margins of excavation may be ornamented with tubercles or tufts of hairs. Last ventral abdominal segment of male truncate or slightly emarginate at apex, without lobe or impression. Aedeagus symmetrical, more or less flattened; apex pointed; orifice covered by a large, sclerotized plate; base without spurs; ventral surface with a broad shallow median groove which is narrowed near tip by a triangular projection from each side.

Length 3.3 to 7 mm.

This genus has been divided by some workers on the basis of the modified male antennae, and *Andrector* has been used as the name for those modified species. This character occurs in several other genera and is not now considered to be of generic importance.

There are 10 species found from southern United States to southern Brazil. As far as known, all feed on beans and other Leguminosae, and several are pests on such crops.

Cerotoma Chevrolat

Cerotoma Chevrolat, 1837, in Dejean, Cat. Coleop., ed. 3, p. 403.

Type: *Crioceris caminea* Fabricius, 1801, designated by Chapuis. 1875, Gen. Coleop., vol. 11, p. 230. (Invalid type: *Crioceris variegata* Fabricius, 1792, designated by Laboissiere, 1939, Mem. Mus. Roy. Hist. Nat. Belgique, ser. 2, fasc. 15, p. 155.)

Cerotana: Bowditch, 1913, Psyche 20:126 (error for *Cerotoma*).

Ceratoma: Guerin, 1953, Coleop. Brasil (error for *Cerotoma*).

Andrector Horn, 1872, Trans. American Ent. Soc. 4:152. Type:

Andrector sexpunctatus Horn, 1872, by monotypy.

Barber, 1945, Bull. Brooklyn Ent. Soc. 40:121-122 (nomen.).—

Hincks, 1950, Ann. Mag. Nat. Hist. (12)3:88 (nomen.).

atrofasciata Jacoby

Ariz., Central America

Cerotoma atrofasciata Jacoby, 1879, Proc. Zool. Soc. London, 1879,

p. 792.—Jacoby, 1888, Biol. Centr.-Amer., Coleop. 6(1):617 (synonym of *ruficornis*).—Ruppel, 1960, *in litt*.

Andrector atrofasciatus (Jacoby), Barber, 1945, Bull. Brooklyn Ent. Soc. 40:122.

ruficornis ruficornis (Olivier)

Fla., West Indies

Crioceris ruficornis Olivier, 1791, Encyc. Meth. 6(1):200.

Galeruca ruficornis (Olivier), Olivier, 1808, Ent. 6:659 (synonym of *denticornis*).

Cerotoma ruficornis (Olivier), Gemminger & Harold, 1876, Cat. Coleop. 12:3592.—Weise, 1885, Arch. f. Nat. 51(1):157.—

Jacoby, 1888, Biol. Centr.-Amer., Coleop. 6(1):616.—Jacoby,

- 1897, Trans. Ent. Soc. London, 1897, p. 277.—Ruppel, 1960, *in litt.*
- Andrector ruficornis* (Olivier), Barber, 1945, Bull. Brooklyn Ent. Soc. 40:122.—Bechyné, 1956, Ent. Arb. Mus. Frey 7:339.
- Galleruca denticornis* Fabricius, 1792, Ent. Syst. 1(2):24.
- Crioceris denticornis* (Fabricius), Fabricius, 1801, Syst. Eleuth. 1:457.
- Galeruca denticornis* (Fabricius), Olivier, 1808, Ent. 6:659.
- Cerotoma denticornis* (Fabricius), Jacquelin-duVal, 1856, in Sagra, Hist. Phys. Pol. Nat. Cuba, vol. 7, Ins., p. 126, fig.—Suffrian 1867, Arch. f. Nat. 33:317.—Gemminger & Harold, 1876, Cat. Coleop. 12:3592 (synonym of *ruficornis*).
- ruficornis sexpunctata* (Horn) Tex., Central American
Andrector sexpunctatus Horn, 1872, Trans. American Ent. Soc. 4:152.—Horn, 1893, Trans. American Ent. Soc. 20:130.—Barber, 1945, Bull. Brooklyn Ent. Soc. 40:122 (synonym of *ruficornis*).
- Cerotoma sexpunctata* (Horn), Gemminger & Harold, 1876, Cat. Coleop. 12:3592.
- Cerotoma ruficornis* subsp. *sexpunctata* (Horn), Ruppel, 1960, *in litt.*
- trifurcata* (Forster) Eastern United States, southern Canada
Chrysomela trifurcata Forster, 1771, Nov. Spec. Ins. 1:29.—Gmelin, 1790, Linne Syst. Nat. 1(4):1774.
- Cerotoma trifurcata* (Forster), Gemminger & Harold, 1876, Cat. Coleop. 12:3592.—Horn, 1893, Trans. American Ent. Soc. 20:129.—Ruppel, 1960, *in litt.*
- Crioceris caminea* Fabricius, 1801, Syst. Eleuth. 1:459.—Gravenhorst, 1807, Vergl. Uebers. Zool. Syst., p. 136.
- Galeruca caminea* (Fabricius), Olivier, 1808, Ent. 6:656, fig.
- Cerotoma caminea* (Fabricius), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 205.—Gemminger & Harold, 1876, Cat. Coleop. 12:3592 (synonym of *trifurcata*)
- Galeruca fibulata* Germar, 1824, Ins. Spec. Nov., p. 601.
- Luperus fibulatus* (Germar), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 209.
- ?*Cerotoma fibulata* (Germar), Horn, 1893, Trans. American Ent. Soc. 20:132 (? synonym of *trifurcata*).
- Biology: McConnell, 1915, Jour. Econ. Ent. 8:261.—Böving, 1930, Proc. Ent. Soc. Washington 32:51-58 (larva).—Isely, 1930, Kansas Agric. Exp. Sta., Bull. 248, pp. 1-20 (morphology, biology).—Eddy & Nettles, 1930, South Carolina Agric. Exp. Sta., Bull. 265, 25 pp. (bionomics).

Key to the North American species of *Cerotoma* Chevrolat

- 1 Male with front deeply excavated; antennal segments 3 and 4 modified; basic color pattern as in figure 31, but color extremely variable through extension or reduction of dark markings..... 2
 Front not excavated nor antennae modified in male; basic color pattern not as in figure 31 but extremely variable; pale areas red or yellow; 3.6-5.5 mm. long; eastern United States to Great Plains, Ariz.; on Leguminosae *trifurcata* (Forster)
- 2 Front, below excavation, without a prominent median tubercle; or if one is present, it is not so high as the lateral tubercles; thin lamella above excavation arcuate, emarginate in middle; 4.5-5.5 mm. long; Ariz., Central America; on Leguminosae... *atrofasciata* Jacoby
- Front, below excavation with a very prominent median tubercle; lamella above excavation nearly square, not or only faintly emarginate; 4.5-5.5 mm. long; Fla., Tex., South America; on Leguminosae
ruficornis (Olivier)

GENUS PHYLLECTHRIS DEJEAN

Form elongate oval. Prothorax distinctly narrower than elytra. Antennae slender, filiform. Male antenna with 10 segments; segment 3 three times as long as 2; segment 4 longer than 3, about as long as 2 and 3 together. Female antenna with 11 segments; segment 3 equal to 2 in length; segment 4 longer than 2 and 3 together. Prothorax broader than long, a little narrower at base; sides nearly straight, with lateral marginal bead. Surface glabrous, with a faint transverse semi-circular depression in basal half in most specimens. Elytra elongate, narrow; sides parallel; humeri not prominent; surface glabrous; punctation confused. Prosternum not extending between coxae. Front coxal cavities open. Male with last ventral abdominal segment slightly truncate, without lobe or emargination, nearly as in female. Middle tibia of male with a notch on inner side near apex. Middle tibia of female normal. Male with apical spurs on middle and hind tibiae, none on front. Female with apical spurs on all tibiae. First segment of hind tarsus longer than segments 2 and 3 together, but not so long as 2, 3, and last together. Tarsal claws appendiculate.

***Phyllecthris* Dejean**

Phyllecthris Dejean, 1837, Cat. Coleop., ed. 3, p. 406 (ed. 2

p. 382). Type: *Galeruca dorsalis* Olivier, 1808, by monotypy. Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 205 (in key to genera and index to volume but not as section heading).—Chapuis, 1875, Gen. Coleop. 11:163-164.—Hincks, 1949, Ann. Mag. Nat. Hist. (12)2:620.

Phyllechthrus, Agassiz, 1846, Nomen. Zool. Index Univ., p. 288 (emendation of *Phyllecthris*).—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 207 (as the section heading but not in key or index to volume).—Gemminger and Harold, 1876, Cat. Coleop. 12:3561.

Phyllechthrus, Horn, 1893, Trans. American Ent. Soc. 20:124. (emendation of *Phyllecthris*).—Horn, 1896, Proc. California Acad. Sci. (2)6:376.—Blatchley, 1910, Coleop. Indiana, p. 1177.—Leng, 1919, Cat. Coleop. America, p. 298.—Weise, 1924, Coleop. Cat., pars 78, p. 108.—Blake, 1958, Proc. U.S. Nat. Mus. 108(3395):69.

Myocera Chevrolat, 1846, in d'Orbigny, Dict. Univ. Hist. Nat. 6:5. Type: *Galeruca dorsalis* Olivier, 1808, by original designation.

dorsalis (Olivier) Pa., Nebr., Ga., Tex.

Galeruca dorsalis Olivier, 1808, Ent. 6:646.

Phyllecthris dorsalis (Olivier), Dejean, 1837, Cat. Coleop., ed. 3, p. 406 (ed. 2, p. 382).—Hincks, 1949, Ann. Mag. Nat. Hist. (12)2:620.

Phyllechthrus dorsalis (Olivier), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 208.

Phyllechthrus dorsalis (Olivier), Horn, 1893, Trans. American Ent. Soc. 20:125.—Horn, 1896, Proc. California Acad. Sci. (2)6:376.—Blake, 1958, Proc. U.S. Nat. Mus. 108(3395):70, fig.

Galleruca atriventris Say, 1824, Proc. Acad. Nat. Sci. Philadelphia 3(2):461.

Phyllechthrus atriventris (Say), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 207.

Phyllechthrus atriventris (Say), Horn, 1893, Trans. American Ent. Soc. 20:125 (synonym of *dorsalis*).—Blake, 1958, Proc. U.S. Nat. Mus. 108(3395):70.

Phyllobrotica atriventris (Say), Leconte, 1883, Complete Writings T. Say 2:224 (on *Amorpha fruticosa*).

gentilis Leconte N.Y., Mont., Tex.

Phyllechthrus gentilis Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 208.

Phyllechthrus gentilis Leconte, Horn, 1893, Trans. American Ent. Soc. 20:127.—Blake, 1958, Proc. U.S. Nat. Mus. 108(3395):71, fig.

Phyllechthrus nigripennis Leconte, 1868, Trans. American Ent. Soc. 2:58.—Blake, 1958, Proc. U.S. Nat. Mus. 108(3395):71 (synonym of *gentilis* Leconte).

Phyllechthrus gentilis var. *nigripennis* Leconte, Horn, 1893, Trans. American Ent. Soc. 20:127.

texanus Leconte

Tex.

Phyllechthrus texanus Leconte, 1884, Trans. American Ent. Soc. 12:28.—Blake, 1958, Proc. U.S. Nat. Mus. 108(3395):72, fig.

Phyllechthrus gentilis var. *texanus* Leconte, Horn, 1893, Trans. American Ent. Soc. 20:127.

Key to the species of *Phyllechthris* Dejean

(From Blake 1958)

- 1 Length 2.5-4 mm. 2
 Length 4.5-6.5 mm.; Pa. to Ga. to Nebr. to Kans.; on
 Amorpha (Leguminosae); (figure 39)
 dorsalis (Olivier)
- 2 Pronotum with wide dark lateral markings; N.Y. to Va.
 to Iowa to Kans.; on *Lespedeza* (Leguminosae)
 gentilis Leconte
 Pronotum entirely pale or with, at most, faint brown
 lateral spotting; Tex. *texanus* Leconte

GENUS LUPEROSOMA JACOBY

Form elongate or elongate oval. Prothorax distinctly narrower than elytra. Male antenna with 11 segments; apical segments more or less distinctly enlarged. Female antenna normal, moderately slender. Prothorax broader than long; sides nearly straight or slightly curved, with lateral marginal bead. Surface glabrous, with a faint transverse depression in basal half or without any impression. Elytra elongate, narrow; sides parallel; humeri not prominent; surface glabrous; punctation confused. Prosternum not extending between coxae. Front coxal cavities open. Male with last ventral abdominal segment slightly truncate, without lobe or emargination, nearly as in female. Middle tibia of male with a notch on inner side near apex. Middle tibia of female normal. Male with apical spurs on middle and hind tibiae but not on front. Female with apical spurs on all tibiae. Tarsal claws appendiculate. Male with first tarsal segment as long as the two following segments together.

Luperosoma is closely related to *Phyllechthris*, and North American species were placed in the latter genus until Mrs. Blake's recent revision of the group. The males of the two genera differ considerably in

the form of the antennae: slender, with only 10 segments in *Phyllecthris*; swollen apically, with 11 segments in *Luperosoma*.

Luperosoma Jacoby

Luperosoma Jacoby, 1891, in Whymper, Trav. Great Andes, Suppl. App., p. 87. Type: *Luperosoma marginata* Jacoby, 1891, by monotypy and original designation.

Blake, 1958, Proc. U.S. Nat. Mus. 108:90.

parallelum (Horn)

Tex., Kans.

Phyllecthrus parallelus Horn, 1893, Trans. American Ent. Soc. 20:126.—Horn, 1896, Proc. California Acad. Sci. (2)6:376.

Luperosoma parallelum (Horn), Blake, 1958, Proc. U.S. Nat. Mus. 108:93.

schwarzi (Horn)

La., Tex.

Phyllecthrus Schwarzi Horn, 1896, Proc. California Acad. Sci. (2)6:376-377.

Luperosoma schwarzi (Horn), Blake, 1958, Proc. U.S. Nat. Mus. 108:95.

subsulcatum (Horn)

Tex., Ariz.

Phyllecthrus subsulcatus Horn, 1893, Trans. American Ent. Soc. 20:126.

Luperosoma subsulcatum (Horn), Blake, 1958, Proc. U.S. Nat. Mus. 108:94.

Key to the species of *Luperosoma* Jacoby

- 1 Elytra vaguely sulcate, coarsely punctate; pronotum evenly convex, may have a small depression each side of middle; male without tubercle on first abdominal segment; 3-4.3 mm. long; Tex. to Ariz.; (figure 35)
subsulcatum (Horn)
- Elytra not sulcate; moderately or finely punctate; pronotum with more or less evident transverse depression 2
- 2 Transverse pronotal depression is before middle; male with a prominent tubercle on first abdominal segment at middle; elytra entirely black; 4.5-5 mm. long; Tex.; on *Helianthus* (Compositae)....*schwarzi* (Horn)
- Transverse pronotal depression is behind middle; elytral punctuation fine; form flattened; sides of elytra parallel; elytra with pale lateral margins; male with front tarsi very short, second segment little longer than first; 4.3-5.2 mm. long; Kans. to Tex.
parallelum (Horn)

GENUS TRACHYSCELIDA HORN

Form broadly oval, very convex. Body and legs yellow; elytra black or dark blue, finely punctate. Antennal segment 3 is a little more than 1.5 times length of 2. Segments 3 and 4 about equal. Pronotum convex without impressions. Front coxal cavities open. All tibiae with apical spurs in both male and female. First segment of hind tarsus of male not quite so long as second and third together. Last ventral abdominal segment truncate at apex in female; broadly, shallowly emarginate in male, without a distinct apical lobe. Aedeagus symmetrical; base without ventral spurs; orifice covered by a very heavily sclerotized plate which reaches nearly to the tip; inner sac with five large spines on each side which may be seen below the plate when the sac is withdrawn. Length 4.5 to 7 mm.

Range. Members of this genus are known from Arizona to Brazil and Bolivia.

The seven species of this genus are very similar to each other, but differ from all other United States species in shape and color. The aedeagus is also quite distinctive. They do not seem to be closely related to any other known genus.

Trachyscelida Horn

Trachyscelida Horn, 1893, Trans. American Ent. Soc. 20:107.

Type: *Agelastica bicolor* Leconte, 1884, by monotypy.

Racenisia Bechyné 1958, Ent. Arb. Mus. Frey 9:604.

Type: *Racenisia venezuelensis* Bechyné, 1958, by original designation. New synonymy.

bicolor (Leconte)

Ariz.

Agelastica bicolor Leconte, 1884, Trans. American Ent. Soc. 12:28.

Trachyscelida bicolor (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:107.

TRACHYSCELIDA BICOLOR (LECONTE)

Figures 57, 60

Body and legs yellow; elytra black, shiny. Antennae dark; basal four segments pale. Aedeagus with apex long, slender, rounded at tip; orifice covered by a long, very slender, pointed, sclerotized plate which reaches nearly to the tip; inner sac with two dorsal and three ventral spines on each side; all spines about same size. Length 5.5 mm.

Type. Male, MCZ type No. 4349, in the Leconte collection. According to Leconte, 1884, this specimen was found at Fort Yuma, Arizona.

Other specimens examined. Two dissected males in the USNM collection bear the following data. "Turrialba, Costa Rica, coll. Schild & Burgdorf" and "Guapiles Sta. Clara 250-300 m., Costa Rica, F. Nevermann, 25-III-35, gekatschert an Gras und Gebusch."

Dr. Horn's 1893 description of *T. bicolor* (Leconte) must have been written in a weak moment for he erred (1) in recognizing the sex of the type, (2) in describing the last ventral abdominal segment, (3) in describing the comparative lengths of the hind tarsal segments, and (4) in failing to see apical spurs on all tibiae.

SUBTRIBE MONOLEPTINA

This subtribe can be distinguished from others by the square or elongate, apical, abdominal lobe of the male. The aedeagus has a sclerotized plate over the apical orifice and has a small basal section with no trace of basal spurs or tubercles. The third antennal segment is usually about the same length as the second or a little longer. The basal segment of the posterior tarsus is longer than all the rest together in most species.

Representatives of this very large, homogeneous group may be found in all parts of the earth, except in the polar regions. Forty-five generic names have been applied to species belonging to this subtribe, but no worldwide study of genera has been made. Many of these names will probably be placed in synonymy when they are better understood.

GENUS CALOMICRUS STEPHENS

Body oval or elongate oval, more or less convex. Prothorax narrower than elytra but in some species only slightly so; pronotum with or without distinct depression; elytral punctation confused; antennae normal, slender; segments not modified; second and third antennal segments equal or third is a little longer than second; fourth at least as long as second and third together. Legs normal; all tibiae of both male and female with apical spurs; first segment of hind tarsus long, in some species longer than all the following together. Last ventral abdominal segment of male with a large, nearly square, apical lobe; front coxal cavities open or closed. Aedeagus symmetrical at orifice and apex; orifice covered with a sclerotized plate; apex in North American species emarginate; base of aedeagus without spurs.

Calomicrus circumfusus Marsham, a small European species, is the type species of this genus. Comparison with the forms listed below indicate there are no differences worthy of use in separating the species into different genera. Consequently, these species are transferred to *Calomicrus*. One of them has been placed in *Calomicrus* before; 14, at one time or another, have been placed in *Luperodes*; 6 in *Luperus*; and 1 in *Monolepta*.

Luperus (figure 158) is distinctly different from *Calomicrus*, as well as the other genera mentioned above, in its lack of a sclerotized plate over the orifice of the aedeagus and the more heavily sclerotized margins of the basal foramen of that organ. It is also a much more slender beetle generally, and has longer, more slender antennae.

Calomicrus, *Luperodes*, *Monolepta*, *Atrachya*, and *Eusattodera* belong to a tremendous complex of nearly 600 species divided among some 30 genera. *Eusattodera* may be separated by the weakly sclerotized base of the orificial plate of the aedeagus, a poor character to say the least. *Calomicrus* and *Luperodes* differ in the comparative length of the first hind tarsal segment, *Calomicrus* having that segment as short as, or shorter than, the following three segments together, and *Luperodes* having that segment longer. This character grades from one extreme to the other and does not seem to be consistent with other characteristics. *Monolepta* has been separated from *Luperodes* and *Calomicrus* by its closed coxal cavities. This does not seem to be a useful character in this group. Examination of the North American species disclosed that (1) the front coxal cavities were open in all examined specimens of *rugosa* Jacoby, *thoracicus* Melsheimer, *luteicollis* Leconte, and *elachistus* Blake; (2) the cavities were closed in all examined specimens of *varicornis* Leconte, *convexus* Blake and *punctatissimus* Blake; (3) some specimens had open cavities and some closed in *brunneus* Crotch, *chiricahuensis* Blake, *blakeae* new name, *ocularis* Blake, *popenoei* Blake, *morulus* Leconte, *intermixtus* Fall, and *atriceps* Horn.

The following species have been placed, at one time or another, in *Luperus*, *Luperodes*, or *Monolepta* but are now transferred out.

Transferred to *Pseudoluperus*: *spretus* Horn, *texanus* Horn, *lecontii* Crotch, *tuberculatus* Blake, *longulus* Leconte, *maculicollis* Leconte, and *wickhami* Horn.

Transferred to *Synetocephalus*: *adenostomatus* White, *atricornis* Fall, *bivittatus* Leconte, *crassicornis* Fall, *curvatus* Fall, *diegensis* Blake, *monorhabdus* Blake, and *vandykei* Blake.

Transferred to *Scelolyperus*: *bimarginatus* Blake, *cyanellus* Leconte, *flavicollis* Leconte, *graptoderoides* Crotch, *laticeps*

Horn, *meracus* Say, *morrisoni* Jacoby, *nigrocyanus* Leconte, *nigrovirescens* Fall, *varipes* Leconte, *smaragdinus* Leconte, *torquatus* Leconte and *transitus* Horn.

Transferred to *Androlyperus*: *californicus* Schaeffer.

Calomicrus Stephens

Calomicrus Stephens, 1831, British Ent., Mandib. 4:293. Type: *Crioceris circumfusus* Marsham, 1802, by monotypy.

Monolepta Chevrolat, 1837, in Dejean, Cat. Coleop., ed. 3, p. 407 (ed. 2, p. 383). Type: *Crioceris bioculata* Fabricius, 1781; designated by Chevrolat, 1845, in d'Orbigny, Dict. Univ. Hist. Nat. 6:5 (*M. pauperata* Erichson, cited in error, was not included in 1837.) New synonymy.

Luperodes Motschulsky, 1858, Etud. Ent. 7:102. Type: *Luperodes alboplagiatus* Motschulsky, 1858, by original designation. New synonymy.

Horn, 1893, Trans. American Ent. Soc. 20:107-118.—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):57-74.

atriceps (Horn) Ariz.

Luperodes atriceps Horn, 1893, Trans. American Ent. Soc. 20:112.
—Weise, 1924, Coleop. Cat., pars 78, p. 109.

blakeae, new name Tex.

Luperodes pallidulus Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 68, fig. (not *Luperodes pallidulus* Baly, 1874, from Japan).

brunneus (Crotch) N.C., Fla., Tex.

Luperus brunneus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:44.

Luperodes brunneus (Crotch), Horn, 1893, Trans. American Ent. Soc. 20:111 (synonym of *varicornis* Leconte).—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):67, fig. (valid species).

Luperodes davisii Leng, 1911, Jour. New York Ent. Soc. 19:194.
—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):67 (synonym of *brunneus* Crotch).

chiricahuensis (Blake) Ariz.

Luperodes chiricahuensis Blake, 1942, Proc. U.S. Nat. Mus. 92 (3139):71, fig.

convexus (Blake) Ill., Okla.

Luperodes convexus Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 71, fig.

elachistus (Blake) N. Mex.

Luperodes elachistus Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 69, fig.

- intermixtus (Fall) N. Mex., Ariz.
Luperodes intermixtus Fall, 1910, Trans. American Ent. Soc. 36:151.—Weise, 1924, Coleop. Cat., pars 78, p. 111.
- luteicollis (Leconte) Colo., N. Mex.
Luperus luteicollis Leconte, 1868, Trans. American Ent. Soc. 2:57.
Luperodes luteicollis (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:110,112.
- morulus (Leconte) Tex.
Luperus morulus Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:210.—Weise, 1924, Coleop. Cat., pars 78, p. 121.
Luperodes morulus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:117.
- ocularis (Blake) Ariz.
Luperodes ocularis Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 72, fig.
- popenoei (Blake) Ariz.
Luperodes popenoei Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 70, fig.
- punctatissimus (Blake) Ariz.
Luperodes punctatissimus Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):69, fig.
- rugosus (Jacoby) Ariz., Mex.
Luperus rugosus Jacoby, 1888, Biol. Centr.-Amer., Coleop., 6(1): 596.—Weise, 1924, Coleop. Cat., pars 78, p. 122.
- thoracicus Melsheimer N.Y., Ga., Kans.
Calomicrus thoracicus Melsheimer, 1847, Proc. Acad. Nat. Sci. Philadelphia 3:162.
Luperus thoracicus (Melsheimer), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:209.
Luperodes thoracicus (Melsheimer), Horn, 1893, Trans. American Ent. Soc. 20:112.—Weise, 1924, Coleop. Cat., pars 78, p. 113.
- varicornis (Leconte) Tex., Ariz.
Luperus varicornis Leconte, 1868, Trans. American Ent. Soc. 2:57.
Luperodes varicornis (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:111.—Weise, 1924, Coleop. Cat., pars 78, p. 113.—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):65, fig.
Monolepta crucigera Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, no. 9, p. 249.—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):65 (synonym of *varicornis* Leconte).
Luperodes marginalis Fall, 1910, Trans. American Ent. Soc. 36: 149.—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):65 (synonym of *varicornis* Leconte).

Key to the species of *Calomicrus* Stephens

- 1 Elytra dark brown or black or dark metallic blue, green,
or purple 2
Elytra entirely or in great part pale brown, yellow, or
testaceous 10
- 2 Pronotum testaceous or light brown, not as dark as the
elytra 3
Pronotum dark brown or black or with metallic luster 5
- 3 Elytra dull blue, strongly alutaceous; 4-4.5 mm. long;
Colo. to N. Mex. *luteicollis* (Leconte)
Elytra dark brown or black; surface shining, not alu-
taceous 4
- 4 Length 4.5-5 mm.; head as dark as elytra; apex of aedeagus
long, narrow, not deeply emarginate; N.Y. to Del. to
Kans.; on cherry (*Prunus*)..... *thoracicus* Melsheimer
Length 2.5-3.5 mm.; head and pronotum same color;
apex of aedeagus deeply emarginate; apical portion
not strongly narrowed; N.C. to Fla. to Tex.
brunneus (Crotch)
- 5 Pronotum with a distinct depression each side of middle,
may be transverse, confluent 6
Pronotum without distinct depressions 7
- 6 Transverse depression of pronotum deep, wide; pronotal
punctuation moderate; pronotum at least as wide at
apex as at base; 3.3-4.5 mm. long; Ariz..... 8
Transverse depression of pronotum very poorly devel-
oped; pronotal punctuation coarse, irregular; pro-
notum slightly narrower at apex than at base; 3.5
mm. long; Ariz. to Mexico..... *rugosa* (Jacoby)
- 7 Elytra dark brown or black; 2.5-3.5 mm. long 9
Elytra with faint blue luster; 3.9-4.3 mm. long;
N. Mex. to Ariz..... *intermixtus* (Fall)
- 8 Aedeagus broad to apex; front very short; head in frontal
view nearly circular; pronotal impressions confluent
across middle; 4-4.3 mm. long; Ariz.
Eusattodera pini (Schaeffer)
Aedeagus narrowed in apical half; front longer; head
in frontal view oval; pronotal impressions separate,
not usually confluent across middle; 3.3-3.8 mm.
long; Ariz. *Eusattodera delta*, new species
- 9 Pronotum and elytra moderately punctuate; antennal seg-
ment 4 distinctly shorter than 2 and 3 together; N.C.

- to Fla. to Tex. *brunneus* (Crotch)
 Pronotum and elytra impunctate or very finely punctate; antennal segment 4 about as long as 2 and 3 together; Tex. *morulus* (Leconte)
- 10 Elytra entirely pale, without darker sutural, lateral, or marginal shadings 11
 Elytra brown or pale yellow, with sutural, lateral, or marginal darker areas 15
- 11 Antennae uniformly dark, without paler basal segments.. 12
 Antennae with basal segments paler than the rest..... 13
- 12 Elongate oval; head, legs, and ventral side brown or yellow; elytra finely punctate; 3.5-4 mm. long; Kans. to Tex. to N. Mex. *popenoei* (Blake)
 Ovale; head, legs, and ventral side of thorax black; elytra moderately punctate; 4-4.5 mm. long; Ariz. *atriceps* (Horn)
- 13 Narrowly oblong; aedeagus spoon-shaped; 3-3.2 mm. long; N. Mex. *elachistus* (Blake)
 Oval; aedeagus not spoon-shaped, with a narrow tip.. 14
- 14 Aedeagus with apical portion long, narrowly compressed, and when viewed from side, irregularly curved; 3.2-4.3 mm. long; Tex..... *blakeae*, new name
 Aedeagus narrow in its entire length and when viewed from side only slightly curved; 2.5-3.5 mm. long; N.C. to Fla. to Tex..... *brunneus* (Crotch)
- 15 Narrowly oblong; 2.6-3.3 mm. long; Ariz. *chiricahuensis* (Blake)
 Ovale 16
- 16 Very conspicuously and densely punctate; 4 mm. long; Ariz. *punctatissimus* (Blake)
 Punctate but not very conspicuously so..... 17
- 17 Interocular distance less than half width of head; eyes large; 2.5-3 mm. long; Ariz..... *ocularis* (Blake)
 Interocular distance more than half width of head.... 18
- 18 Aedeagus very narrow in most of its length when viewed from above; elytra with suture more or less darkened and often with a median brownish area sometimes extending across it; 2.6-3.4 mm. long; Tex. to Ariz. *varicornis* (Leconte)
 Aedeagus broader, narrowed only toward tip; elytra pale without dark shadings, except sutural and marginal areas 19

- 19 Aedeagus deeply emarginate at apex; 2.5-3.5 mm. long;
 N.C. to Fla. to Tex.....*brunneus* (Crotch)
 Aedeagus not deeply emarginate at apex; 3-4 mm. long;
 Ill. to Okla. *convexus* (Blake)

CALOMICRUS MORULUS (LECONTE)

The author has examined the MCZ type No. 4345 of this species and a series of seven males and one female in the Ulke collection in the Carnegie Museum, all from Texas. *C. morulus* is very similar to *C. brunneus* (Crotch), and the two names may represent a single species, but until more material can be examined, it is better to consider them to be separate. *C. morulus* is a little more nearly black than *brunneus*, although Florida specimens of the latter may be nearly black. The elytral punctation of *morulus* is very fine, while that of *brunneus* is moderate. In *morulus* antennal segment 4 is about equal in length to 2 and 3 together; in *brunneus* antennal segment 4 is distinctly shorter than 2 and 3 together. There seems to be no significant difference between the aedeagi of the two species. In most of the specimens of *morulus* the front coxal cavities are closed, but in two the cavities are open.

CALOMICRUS RUGOSUS (JACOBY)

Jacoby described this species as follows: "Black, above dark bluish- or greenish-black; head, thorax, and elytra closely rugose-punctate.

"Head strongly rugose at the vertex; the frontal tubercles and carina distinct, the latter short; antennae two thirds the length of the body in the male, shorter in the female, black, the third joint about one-half longer than the second; thorax about one half broader than long, the sides perfectly straight, the posterior margin slightly rounded, the surface unevenly rugose and punctured, the middle of the disc sometimes with some smooth round spaces and a short ridge near the base; scutellum black, smooth; elytra strongly and closely punctured, the interstices wrinkled throughout, the epipleurae continued below the middle; the underside and the legs black, finely pubescent; the tibiae mucronate, the posterior pair with a long spine; the first joint of the posterior tarsi as long as the following three joints united; claws appendiculate; the anterior coxal cavities incomplete. Length $1\frac{1}{2}$ to 2 lines [3.2-4.3 mm.]. *Hab.* Mexico, Presidio, Ventanas, Ciudad in Durango (Forrer)."

There are several specimens of this species in the Fall (MCZ) collection from Arizona. These are labelled "*Eusattodera* n. sp."

GENUS EUSATTODERA SCHAEFFER

Body elongate oval; prothorax narrower than elytra. Upper surface glabrous or with a few scattered hairs; dark blue or blue-green. Head normal in male. Ocular sulcus distinct, interocular sulcus deep behind tubercles. Frontal tubercles moderately swollen. Interantennal carina narrow, acute. Antennae reach apical third of elytra in male, slender, not modified; segment 2 short; segment 3 very little longer than 2; segment 4 about twice as long as 3, about as long as 2 and 3 together. Pronotum about 1.5 times wider than long; disc with a very distinct depression on each side of middle, may be confluent. Elytra moderately convex, not modified. Epipleura moderately wide at base, narrowed rather abruptly just before middle, narrow but distinct to sutural angle. Male with legs normal; apical spurs on all tibiae; claws appendiculate. Prosternum not extending between coxae. Front coxal cavities usually open but may be closed in some specimens. Mandibular teeth 1, 2, and 3 normal. Last ventral abdominal segment of male with a large, nearly square, slightly depressed, apical lobe. Aedeagus symmetrical, without basal spurs; apex finely emarginate at tip; orifice covered by a long, slender sclerotized plate; base of plate membranous. Length 3.2 to 4.3 mm.

Two species are known, both from the mountainous regions of Arizona. Schaeffer recorded the type species from pine.

The two species of this genus are very close, but males can be separated easily. They are also similar to some of the species of *Calomicrus*, particularly *rugosus* Jacoby and *intermixtus* Leconte. However, the base of the orificial hood of the aedeagus is membranous, not as heavily sclerotized as in *Calomicrus*. This may be an inconsistent character; but until more species are examined, it can be used as the diagnostic character for *Eusattodera*.

Eusattodera Schaeffer

Eusattodera Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, no. 9, p. 244. Type: *Eusattodera pini* Schaeffer, 1906, by monotypy.

pini Schaeffer Ariz.

Eusattodera pini Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, no. 9, p. 244.

delta, new species Ariz.

Key to the species of Eusattodera Schaeffer

Aedeagus broad to apex; frons very short; head in frontal view circular; pronotal impressions confluent across the middle; 4-4.3

mm. long *pini* Schaeffer
 Aedeagus narrowed in apical half; frons longer; head in frontal
 view is oval; pronotal impressions separate, not usually confluent
 across middle; 3.3-3.8 mm. long..... *delta*, new species

EUSATTODERA DELTA, NEW SPECIES

Form elongate oval; prothorax narrower than elytra. Upper surface dark metallic blue or blue-green, glabrous or with a few scattered hairs on apical half of elytra. Antennae, tibiae, and tarsi yellow.

Head normal in male. Vertex moderately punctate. Eyes moderate in size, with a few erect hairs. Ocular sulcus distinct; coronal suture indistinct; interocular sulcus deep behind tubercles. Frontal tubercles moderately swollen, triangular, smooth, separated from each other by a narrow sulcus, not distinctly separated from orbit or interantennal carina. Interantennal carina narrow, strongly declivous in front. Antennae reach apical third of elytra in male, slender, not modified; segment 2 short; segment 3 very little longer than 2; segment 4 about twice as long as 3, about as long as segments 2 and 3 together.

Pronotum with width about 1.5 times length; sides and base moderately curved, with a few scattered hairs; apical angles thickened, not prominent; basal angles obtuse. Surface finely punctate; shining; with a broad, deep depression on each side of middle; median area between depression slightly depressed also. Scutellum small, smooth. Elytra moderately, evenly convex, without distinct sulcus between humerus and disc; coarsely punctate, with a few scattered, erect hairs which are arranged in four more or less distinct longitudinal rows. The lateral row extending from apex to humerus. Margins also with a few hairs.

Epipleura moderately wide at base, narrowed rather abruptly just before middle, narrow but distinct to sutural angle. Legs normal, slender. Apical spurs on all tibiae in both male and female. Claws appendiculate. Prosternum not extending between coxae. Front coxal cavities usually open but may be closed in some specimens. Mandibular teeth 1, 2, and 3 normal. Apical lobe of male last ventral abdominal segment large, broader than long, slightly depressed.

Aedeagus symmetrical, without basal spurs; apex very finely emarginate at tip; apical half much narrower than basal half; orifice covered by a long, slender sclerotized plate; base of plate membranous.

Length 3.3 to 3.8 mm.

Holotype. ♂, Chiricahua Mts., Ariz., July 22, 1927, 8,000 ft., Turkey Flat, Cochise Co., J. A. Kresche, #566 (CAS).

Paratypes. 1 ♂, same data (W); 2 ♂♂, 1 ♀, Chiracahua Mts., Ariz., July 15, 1927, 8-9,000 ft., Barefoot Park, Cochise Co., J. A. Kusche (CAS); 1 ♀, Texas Pass, Ariz., Dragon Mts., July 19-21, 1917 (CORNELL); 2 ♂♂, Mt. Lemmon, St. Catalina Mts., Ariz. (CAS) 1 ♀, Bear Wallow, Mt. Lemmon, 6-22-'53, A. & H. Dietrich (CORNELL).

Eusattodera delta is quite similar to *pini* Schaeffer in general appearance but differs in the characters listed in the key. It is probably placed under the name *pini* in collections.

EUSATTODERA PINI SCHAEFFER

The description of *E. delta* will fit *E. pini* very well, except for the following characteristics. In *pini* the pronotum is moderately punctate, less shiny than in *delta*. The pronotal impressions are confluent across the middle. The face is very short, the head in frontal view nearly circular. The apical lobe of the last ventral abdominal segment of the male is nearly square. The apical third of the aedeagus is as wide as the basal third; the organ is somewhat narrowed in the middle.

Length 4 to 4.3 mm.

Specimens examined. 1 ♀, Huachuca Mts., Ariz., VII-20, Brooklyn Museum Coll. 1929, cotype No. 42318 U.S.N.M. (USNM); this specimen is hereby designated the lectotype. 1 ♂, Huachuca Mts., Carr Cn., Ariz., VIII-6-1924, J. O. Martin (CAS); 1 ♀, same data, VII-7-30 (CAS).

The male mentioned above has closed front coxal cavities, but the Carr Canon female has open cavities.

SUBTRIBE LUPERINA

The members of this subtribe are generally elongate beetles which are slightly to moderately convex. There is usually a broad, rectangular lobe on the apex of the last ventral abdominal segment of the male. The aedeagus is symmetrical. It does not have basal spurs, although the margins of the basal foramen are usually thickened and provided with an angle or tubercle on each side. The dorsal surface of the beetle is very rarely pubescent.

Relationships between the genera have not yet been satisfactorily determined. The following groups are tentative. The Phyllobroticities are primarily Asian. Only *Phyllobrotica* extends into North America. The Exosomites constitute a poorly defined group including *Pteleon* as its only American representative. The rest of the American

Luperina are here placed in the Scelidites, a group which is strictly American, except for *Scelolyperus*, also found in central Asia.

GENUS SCELIDA CHAPUIS

Body moderately elongate; sides of elytra nearly parallel; pronotum narrower than elytra. Elytra may be pale but usually bright metallic blue, green, purple, or cupreous; pronotum pale; head and legs variable. Front coxal cavities open. Prosternum very narrow between coxae. Tarsal claws appendiculate. All tibiae lacking apical spurs in both male and female. Last ventral segment of female simply rounded; that of male with a short, more or less rectangular lobe at apex. Aedeagus symmetrical, pointed; orifice not covered by a sclerotized plate; base without free spurs. Length 6.0 to 12.7 mm. One or two pairs of long appendages may be attached to the ventral abdominal segments of the males of some species.

This group deserves full generic status. It is not a synonym of *Scelolyperus* as claimed by Horn; in fact, it does not seem to be closely related to *Scelolyperus*. The following species are included in *Scelida*: *Scelida elegans* Chapuis, *Scelida bellus* Jacoby, *Scelida metallicus* Jacoby, *Scelida viridis* Jacoby, *Scelida balyi* Jacoby, *Scelolyperus flaviceps* Horn, *Scelolyperus tenuimarginatus* Bowditch, and a new species, *Scelida mimula*. These are all neotropical, except *mimula* and *flaviceps* which occur in Arizona. The four Mexican species which Jacoby placed in *Cneorane* probably belong here also.

Scelolyperus rosenbergi Bowditch is a typical *Chthoneis*, judging by the unique female type. Its name becomes a junior homonym when transferred to *Chthoneis*, therefore the new name, *Chthoneis bowditchi* is provided here to replace *Scelolyperus rosenbergi*. *Scelida flava* Allard is a *Chthoneis* also but does not belong to the typical subgenus.

Scelida Chapuis

Scelida Chapuis, 1875, Gen. Coleop. 11:184. Type: *Scelida elegans* Chapuis, 1875, by monotypy. Jacoby, 1888, Biol. Centr.-Amer., Coleop. 6(1):606.

flaviceps (Horn) Ariz.

Scelolyperus flaviceps Horn, 1893, Trans. American Ent. Soc. 20:103.

mimula, new species Ariz.

Key to the North American species of *Scelida* Chapuis

Male with a pair of large appendages on the abdomen; metastern-

num and abdomen usually dark; elytra usually bright green; 6.8 mm. long.....*flaviceps* (Horn)
 Male with simple abdomen; metasternum and abdomen usually pale; elytra usually dark blue or blue green; 4.5-6.5 mm. long
mimula, new species

SCELIDA MIMULA, NEW SPECIES

Figure 58

Body moderately elongate; sides of elytra parallel; elytra distinctly wider than pronotum. Elytra bright metallic blue or blue green, rarely testaceous; head, pronotum, and femora testaceous; antennae, tibiae, and tarsi black.

Head impunctate, shiny. Frontal tubercles swollen, delimited behind by the deep interocular sulcus which terminates each side in a deep, more or less circular, depression. Interantennal carina moderately developed. Interocular distance half width of head across eyes. Eyes with a few scattered, erect hairs. Antennae slender, dark brown; basal three segments pale with dorsal, apical areas black. Third segment twice as long as second; fourth three times as long as second; fifth through eleventh subequal, shorter than fourth. Length of pronotum slightly less than width. Sides parallel in basal two-thirds, converging toward apex. Apex narrower than base. Angles obtuse; base nearly straight, slightly emarginate in median three quarters. Surface moderately convex, impunctate, shiny. Elytra half again as wide as pronotum. Length of each elytron over three times width. Surface strongly convex; finely, densely punctate; disc rugulose; a faint depression across basal fifth; sparse, fine, erect pubescence scattered over apical half. Epipleura narrow, reaching apical angles. Pro- and mesosterna glabrous. Prosternum very narrow between front coxae. Front coxal cavities open. Metasternum and abdomen pubescent. Femora testaceous, except at apex; tibiae and tarsi black or brown. All tibiae lacking apical spurs in both male and female. Tarsal claws appendiculate.

Male. Metasternum dark brown. Abdomen dark brown; without appendages; with a broad, deep depression at middle of first segment. Last segment with a short, broad, rectangular apical lobe. Length of lobe one-fourth width and one-fifth length of segment. Lobe covered with dense pubescence. Posterior tibia slightly arcuate, bent near middle. First segment of front tarsus one-fourth length of tibia, as long as second and third together. First segment of hind tarsus one-third length of tibia, longer than second and third together but not so long as second, third, and last together. Aedeagus symmetrical, long,

slender, flat, moderately arcuate, except for tip which is abruptly turned up. Apex narrowed but not acutely pointed. Orifice near apex, not covered with sclerotized plate. Base lacking spurs, although rounded tubercles are present.

Female. Ventral surface usually entirely pale. Abdomen normal; last ventral segment evenly rounded at apex. Posterior tibiae straight. First segment of front tarsus one-fifth length of tibia, not so long as second and third together. First segment of hind tarsus one-fourth length of tibia, almost but not quite so long as second and third together.

Length 4.5 to 6.5 mm., width 2.0 to 2.5 mm.

Holotype. Male, Sabino Can., Ariz., July 11, 1949, D. J. and J. N. Knull (OSU).

Paratypes. The following specimens from Arizona were collected by D. J. & J. N. Knull: 5 ♂♂, 23 ♀♀, Sabino Can., VII-5-55 (OSU); 9 ♂♂, 5 ♀♀, Chiricahua Mts., VII-24-55 (OSU); 5 ♂♂, 1 ♀, Chiricahua Mts., VII-17-57 (OSU); 1 ♂, 1 ♀, Chiricahua Mts., VII-23-59 (OSU); 8 ♀♀, Sabino Can., VII-11-49 (OSU); 3 ♂♂, 7 ♀♀, Tucson, August 13, 1936 (OSU, W); 2 ♂♂, 6 ♀♀, Tucson, VII-12-37 (OSU); 1 ♂, Tucson, VII-20-40 (OSU). The following specimens in the University of Arizona collection were taken by Werner & Nutting in Arizona: 1 ♂, 1 ♀, Sabino Can., Sta. Cat. Mts., July 15, 1949. There are 1 ♂ and 2 ♀♀ in the Cornell collection labeled Madera Canyon 4880; Santa Rita Mts., Santa Cruz Co., Ariz., 1-20 July 1959, J. G. Franclement (CORNELL).

Aside from the male characters, the two Arizona species of *Scelida* are very nearly identical. In female *mimula* the abdomen is very rarely dark and then without green luster; it is also smoother, less alutaceous. The elytra are black, dark blue, or dark blue-green. The writer has not seen any with the bright green typical of *flaviceps*. The elytral punctuation, especially on the disc near the suture, is a little more distinct than in *flaviceps* and less likely to be obscured by the rugose surface of the elytra.

In general appearance, *S. flaviceps* is quite similar to *S. mimula*.

SCELIDA FLAVICEPS (HORN)

Figures 52, 53, 54, 56

Males are easily distinguished by characters of the abdomen and aedeagus, but females are not easy to identify, except possibly by the color of the abdomen. The description below lists only characters which serve to distinguish the two species.

The elytra are usually bright metallic green, rarely blue or blue-green.

Male. Posterior margin of second ventral abdominal segment greatly produced, forming two large appendages which reach beyond the last ventral segment; each appendage with a deep inner groove. Segments 3, 4, and 5 short; segment 5 with wide circular area which is depressed, smooth, and glabrous. Last dorsal segment strongly deflected downward. First segment of front tarsus one-fifth length of tibia, not quite so long as second and third together. First segment of hind tarsus one-fourth length of tibia, as long as second and third together. Aedeagus symmetrical; orifice at apical sixth, without sclerotized plate. Apex pointed, constricted (dorsal view) at apical tenth; sides barbed opposite orifice; two prominent dorsal carinae running from apex, around orifice, to about middle of organ. Ventral surface with deep depression in apical third.

Female. Apex of scutellum acute, while that of *mimula* is more rounded. Eyes more distinctly pubescent than in *mimula*. Metasternum and abdomen usually dark, distinctly blue or green. Surface of abdomen, at least on sides, more distinctly alutaceous. Posterior tibiae more slender. First segment of hind tarsus longer than second and third together but not so long as second, third, and last together. Apical segment of maxillary palp nearly twice as long as penultimate, while in *mimula* these segments are about equal.

Length 6.8 mm., width 2.7 mm.

Type. The female lectotype, No. 3799, in the Horn collection at the Philadelphia Academy of Sciences is labeled "Ariz."

Other specimens examined. ARIZONA: 2 ♂♂, Chiricahua Mts., July 20, 1953, D. J. and J. N. Knull (OSU, W); 1 ♂, 1 ♀, Stockton Pass, Pinaleno Mts., August 4, 1948, Nutting and Werner (U. ARIZ.); 27 ♂♂, 28 ♀♀, Chiricahua Mts., July, D. J. and J. N. Knull (OSU, W).

Scelida balyi Jacoby, from Central America, also has large abdominal appendages, but in this species the appendages are longer, narrower, and dissected, more feathery in appearance.

GENUS ANDROLYPERUS CROTCH

Form elongate oval; palpi rather stout, terminal segment conical, acute at tip. Antennae slender; third segment longer than second, shorter than fourth; pronotum subquadrate, broader than long, widest at apical third; surface without depressions. Elytra oval, broader in male; lateral margin in male with deep incision at apical angle surrounded by long pubescence. Epipleura broad at base, ex-

tending to incisure or to apical angle in female; anterior coxal cavities open; prosternum extending narrowly between coxae; tarsal claws appendiculate; anterior tibiae without terminal spurs; spurs present on middle and hind tibiae in male and female; first segment of posterior tarsi as long as following two segments together. Last ventral abdominal segment of male with a very short, depressed apical lobe. Aedeagus symmetrical, without basal spurs; orifice without sclerotized plate; inner sac covered in large part by small, dark cornuti.

Yellow or red with black or dark brown markings. The male of *A. fulvus* has two pairs of long, slender appendages extending from the ventral abdominal segments. Length 4 to 9 mm.

The 5 species of this genus are known from the southwestern United States.

The elytral incisure in the male is quite distinctive. *Androlyperus* is related to *Scelida* and *Pseudoluperus*.

Androlyperus Crotch

Androlyperus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:55. Type: *Androlyperus fulvus* Crotch, 1873, by monotypy.

Malacamerus Wilcox, 1951, Ohio Jour. Sci. 51:93. Type: *Androlyperus maculatus* Leconte, 1883, by original designation. Arnett, 1962, Beetles of United States, p. 934 (synonym of *Androlyperus* Crotch).

californicus (Schaeffer)

Calif.

Luperodes californicus Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, p. 245.—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 58, fig.

fulvus Crotch

Calif.

Androlyperus fulvus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:55.—Horn, 1893, Trans. American Ent. Soc. 20:119.

incisus Schaeffer

Ariz., Calif.

Androlyperus incisus Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, p. 247.

maculatus Leconte

Calif.

Androlyperus maculatus Leconte, 1883, in Leconte & Horn, Class. Coleop. N. America, p. 349.—Leconte, 1884, Trans. American Ent. Soc. 12:28.

Malacosoma cimex Allard, 1889, Bull. Soc. Ent. Belgique 33:68.—Horn, 1893, Trans. American Ent. Soc. 20:121 (synonym of *maculatus*).

Malacorhinus maculatus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:121.

Malacamerus maculatus (Leconte), Wilcox, 1951, Ohio Jour. Sci. 51:93, fig.

nigrescens (Schaeffer) Utah

Malacorhinus nigrescens Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, p. 246.

Malacamerus nigrescens (Schaeffer), Wilcox, 1951, Ohio Jour. Sci. 51:93.

Key to the species of *Androlyperus* Crotch

- 1 Elytra entirely black; 4-4.5 mm. long; Ariz. to Calif.
incisus (Schaeffer)
- 2 Elytra at least partially pale 2
- 2 Each elytron red with a distinct black spot before middle and another at apical third; abdomen of male normal; 7-9 mm. long; Calif.....*maculatus* Leconte
- Elytra without distinctly delimited markings; if maculate, then the elytra are pale brownish yellow..... 3
- 3 Male with four long slender abdominal appendages; head black; pronotum and elytra pale brownish yellow; elytra may have a poorly defined dark spot in apical half; 4.5-7 mm. long; Calif.; (figures 42, 43, 44)
fulvus Crotch
- Abdomen of male without appendages 4
- 4 Elytra dark with suture and margins red; 5 mm. long; Utah*nigrescens* (Schaeffer)
- Elytra pale with suture and margins usually dark; 3.7-5.8 mm. long; Calif.....*californicus* (Schaeffer)

ANDROLYPERUS FULVUS CROTCH

Figures 42, 43, 44

A reexamination of specimens of *Androlyperus fulvus* Crotch showed that both male and female have apical spurs on middle and hind tibiae though none are on the front tibiae. In this respect, and in the marginal elytral incision, *fulvus* agrees with *maculatus* Leconte, type species of *Malacamerus*. Although *fulvus* is rather unique in having two pairs of long, slender abdominal appendages, the writer does not believe that this character is of generic significance. Consequently, *Malacamerus* is hereby rejected as a synonym of *Androlyperus*.

ANDROLYPERUS CALIFORNICUS (SCHAEFFER)

Since the elytral incision is present in *Luperodes californicus* Schaeffer, this species is placed in *Androlyperus* also.

GENUS PSEUDOLUPERUS BELLER & HATCH

Elongate or oval; sides of elytra parallel; prothorax narrower than elytra. Elytral punctation confused. Antennae about two-thirds length of body. Third antennal segment much longer than second, nearly as long or longer than fourth. Frontal tubercles swollen; interantennal carina prominent, convex. Frontal sulcus deep. All tibiae, in both male and female, with apical spurs or all lacking spurs. Tarsal claws appendiculate. First segment of hind tarsus longer than second and third together, but not so long as all following together, slightly less than one-third length of tibia. Prosternum extending very narrowly between coxae or not at all. Front coxal cavities open. In male last ventral abdominal segment with apex at middle truncate; depressed with a short, broad, rectangular lobe. Aedeagus symmetrical, usually gradually narrowing to acute apex, without sclerotized orificial plate; basal spurs absent or represented by small tubercles.

The species of this genus are more nearly like the European *Luperus* than are any others of the American fauna. They differ in being slightly broader, with shorter antennae in the male, different proportions of the basal antennal segments, different form of last ventral abdominal segment of male, and in form of the aedeagus.

In typical *Luperus* (*flavipes* Linnaeus) the third segment of the male antenna is over three times the length of the second and about half the length of the fourth. The last ventral abdominal segment of the male has a rather large, median, apical lobe, and a broad, deep depression running the length of the segment. The apex of the aedeagus is broader than the rest of the organ, evenly rounded, with acute lateral apical angles.

Pseudoluperus, as here constituted, is a very mixed group. Further study of the species and their relatives may show a necessity of splitting the genus. It is very close to *Synetocephalus*, differing in the darker coloration, narrower head, and the lack of a sclerotized plate over the orifice of the aedeagus. *Synetocephalus crassicornis* (Fall) also lacks the sclerotized plate but is entirely pale above.

Pseudoluperus Beller & Hatch

Pseudoluperus Beller & Hatch, 1932, Univ. Washington Publ. Biol. 1(2):115. Type: *Pseudoluperus bakeri* Beller & Hatch, 1932, by monotypy.

- cyanellus* (Horn) Ariz., Mex. (Baja Calif.)
Scelolyperus cyanellus Horn, 1895, Proc. California Acad. Sci. (2)5:251.
- decipiens* (Horn) Calif.
Scelolyperus decipiens Horn, 1893, Trans. American Ent. Soc. 20:106.
- fulgidus* new species Tex.
- lecontii* (Crotch) B.C., Ariz.
Luperus rufipes Leconte, 1859, Smithson. Contr. Knowl. 11:27.
Luperus lecontii Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia 25:54.
Luperodes Lecontii (Crotch), Horn, 1893, Trans. American Ent. Soc. 20:115.
Luperus Lecontei Crotch, Weise, 1924, Coleop. Cat., pars 78, p. 119.
Luperus pallipes Beller and Hatch, 1932, Univ. Washington Publ. Biol. 1:113. New synonymy.
Luperodes lecontei asclepiadis Schaeffer, 1932, Canadian Ent. 64:238.
- linus*, new species Tex.
- longulus* (Leconte) Nebr. to Wash. to Calif.
Luperus longulus Leconte, 1857, preprint of 1860, Reports Expl. and Surv. for Railroad from Mississippi R. to Pacific Ocean, vol. 9, pt. 3, no. 1, p. 69.
Scelolyperus longulus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:106.
Pseudoluperus bakeri Beller & Hatch, 1932, Univ. Washington Publ. Biol. 1(2):115. New synonymy.
- maculicollis* (Leconte) Calif.
Luperus maculicollis Leconte, 1887, Trans. American Ent. Soc. 12:271.
Scelolyperus maculicollis (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:105.
- spretus* (Horn) Tex.
Luperodes spretus Horn, 1893, Trans. American Ent. Soc. 20:117.
- texanus* (Horn) Tex.
Luperodes texanus Horn, 1893, Trans. American Ent. Soc. 20:113.
- tuberculatus* (Blake) Calif.
Luperodes tuberculatus Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):62, fig.
- wallacei*, new species Utah
- wickhami* (Horn) Ariz.

Luperodes Wickhami Horn, 1893, Trans. American Ent. Soc. 20:114.

Luperus Wickhami (Horn), Weise, 1924, Coleop. Cat., pars 78, p. 123.

Key to the species of *Pseudoluperus* Beller & Hatch

- | | | |
|---|---|-----------------------|
| 1 | Elytra, at least in part, pale..... | 2 |
| | Elytra entirely dark; may be dark brown, black, blue-green, or violet | 4 |
| 2 | Elytra yellow with a submarginal or discal dark stripe.... | 3 |
| | Upper surface brownish yellow; elytra with very faint greenish luster; 3.7-4 mm. long; Ariz., Baja Calif. | |
| | <i>cyanellus</i> (Horn) | |
| 3 | Head, abdomen, and legs black; male abdomen normal; each elytron pale with all margins and one median longitudinal stripe black; 4.5 mm. long; Tex. | |
| | <i>linus</i> , new species | |
| | Head, abdomen, and legs pale; male abdomen with a pair of tubercles on the second segment; each elytron pale with suture and a narrow lateral, longitudinal stripe dark; 4-4.5 mm. long; Calif... <i>tuberculatus</i> (Blake) | |
| 4 | Pronotum entirely dark | 5 |
| | Pronotum entirely or partly pale | 11 |
| 5 | Posterior and middle legs with apical tibial spurs..... | 6 |
| | Posterior and middle legs without apical tibial spurs | 8 |
| 6 | Elytra distinctly dark blue or blue-green; pronotum black; legs usually entirely pale; aedeagus, in lateral view, appears to be bent at middle; 4.5-5 mm. long; B.C. to Ariz.; on <i>Apocynum</i> , <i>Psoralea</i> (?)... <i>lecontii</i> (Crotch) | |
| | Elytra and pronotum same color..... | 7 |
| 7 | Elytra, pronotum, and vertex with more or less distinct greenish bronze luster; frontal tubercles indistinct, poorly delimited; 3.2 mm. long; Utah | |
| | <i>wallacei</i> , new species | |
| | Elytra, pronotum, and vertex black or dark brown, without green or bronze luster; frontal tubercles well delimited by narrow but deep grooves; 4 mm. long; Tex. | <i>spretus</i> (Horn) |
| 8 | Elytra with distinct blue, green, or purple luster..... | 9 |
| | Elytra black or dark brown, may have extremely faint greenish luster | 10 |
| 9 | Small, 3.7-4 mm. long; pronotum and elytra dark steel | |

strongly curved in apical half. Surface evenly convex, finely punctulate, shining. Scutellum smooth, shining. Elytral surface finely, closely punctuate; strongly shining; with a few scattered erect hairs. Abdomen of male with a depressed, semicircular area at apex. This area is less than half the length of the segment. Apex with a very short, depressed, pubescent, rectangular lobe. Last ventral segment of female evenly rounded and convex.

Front coxal cavities open. Prosternum narrowly separating front coxae. All tibiae of male lack apical spurs; all tibiae of female with prominent, broad spurs. Tarsi unmodified; first segment of hind tarsus slightly less than length of following two segments together, about one-fourth the length of tibiae. Tarsal claws appendiculate. Aedeagus narrow, symmetrical, rather abruptly pointed; tip strongly bent down. Orifice not covered with sclerotized plate. Base without ventral spurs.

Length 3.7 to 4 mm.; width 1.5 to 1.6 mm.

Range. This species is known from Baja California and Arizona.

The paratype and another Lower California specimen in the Horn collection are entirely dark brown; frons and base of antennae testaceous. The elytra have a more or less distinct blue or purple luster. In another long series from Baja California (CAS), all the females are entirely pale. All of the specimens from Arizona which the writer has seen are entirely pale or pale with very faintly darkened lateral and sutural margins. There is a possibility that the pale form should be considered a distinct subspecies or species, but more information concerning the biology of the species is necessary to settle this question.

This species is very closely related to *P. maculicollis* (Leconte), differing in coloration and its smaller size.

PSEUDOLUPERUS DECIPIENS (HORN)

Figures 47, 51

Form elongate; sides of elytra parallel; prothorax distinctly narrower than elytra. Body and legs entirely dark brown. Antenna brown, except for segments 2, 3, and 4 and the under side of segments 1 and 5 which are yellow. Apical antennal segments of male widened, flattened below.

Head normal in male; eyes small; interocular distance is equal to two-thirds width of head across eyes. Ocular sulcus broad, shallow, sparsely pubescent. Supratentoria very small, indistinct, recognizable only by the hair which is three times as long as surrounding hairs. Coronal suture indistinct. Interocular sulcus broad, deeply impressed.

Frontal tubercles large, strongly swollen; surface smooth, shiny; separated from each other by a narrow, moderately deep sulcus; separated from orbit by several, small, longitudinal sulci. Orbit more or less delimited from tubercles by a row of hairs. Front short. Inter-antennal carina distinct, moderately convex, not extending between tubercles. Transverse frontal carina distinct, strongly declivous in front. Genae short, as long as two facets of eye at narrowest portion.

Antennae reach middle of elytra, rather robust; apical segments distinctly broader than in related species. Width of tenth segment about equal to length of second. Segment 2 small; segments 3 and 4 equal, distinctly but slightly longer than 2. Basal segment strongly swollen.

Pronotal width is 1.2 times length, widest at apical third; sides and base evenly curved. Apical and basal margins densely pubescent; sides pubescent but less densely so. Surface of pronotum moderately, evenly convex; without impressions; extremely finely punctulate, with a few scattered hairs; this pubescence indistinct. Scutellum triangular, rounded at apex, impunctate.

Elytra very finely punctate, an extremely small hair in each puncture; pubescence slightly more distinct in apical half. Humeri prominent, with a broad, shallow sulcus separating them from disc. Disc with several very indistinct longitudinal sulci.

Epipleura moderately wide at base, very gradually narrowed, distinct to apical angles. Legs normal in male; apical spurs absent from all male tibiae. Prosternum extending narrowly between front coxae; front coxal cavities widely open. Last ventral abdominal segment of male with a short depressed apical lobe. Aedeagus symmetrical, slender in apical half, pointed at apex; orifice not covered by a sclerotized plate; base without free spurs.

Length 4 mm.

Type. The type is in the Horn collection, Academy of Natural Sciences of Philadelphia.

Other specimens examined. The description above was drawn from a male specimen in the Horn collection (PHILA.) labeled "Cal." "Horn Coll. H 10384."

The Horn specimens are the only ones the writer has seen. They are very close to *P. longulus*, differing primarily in the swollen apical antennal segments. The aedeagus is slightly narrower in apical half than in *longulus*. Otherwise, the two species are nearly identical. *P. longulus*, as here described, is a very variable insect. A female of *decipiens* has not been recognized but it may not be separable from *longulus*.

PSEUDOLUPERUS FULGIDUS, NEW SPECIES**Figures 62, 63**

Elongate oval; pronotum narrower than elytra. Elytra dark blue, shiny; head (except vertex) and pronotum testaceous; ventral side (except prosternum) and legs black.

Head testaceous; labrum and a spot each side of vertex darker. Surface smooth, shiny. Frontal tubercles strongly swollen; delimited behind by a deep, sinuous, interocular groove. Eyes small. Interantennal carina broad, moderately convex. Interantennal distance five-eighths width of head across eyes. Antennae dark brown; basal three segments paler. Third segment one and one-half times as long as second; fourth longer than third but not so long as second and third together. Antenna reach middle of elytra.

Pronotum nearly impunctate, smooth, shiny; widest at apical third; sides in basal half straight, converging. Angles not produced; posterior angle obtuse. Scutellum black, broadly rounded, smooth. Length of each elytron a little more than three times width. Elytra with sides parallel in basal two-thirds; slightly wider at apical quarter; convex; with faint indication of a lateral, longitudinal carina; elytra together wider than pronotum at base. Humeri prominent, delimited by a rather evident depression. A more or less evident transverse depression at basal fifth. Surface alutaceous, with very fine, close punctures. A few erect hairs scattered over apical half.

Prosternum testaceous, smooth, shiny, not extending between front coxae which are contiguous. Front coxal cavities open. Meso-, metasternum, and abdomen shining black, sparsely pubescent. Last ventral abdominal segment with a very short, broad, median lobe; slightly depressed; apex on each side of lobe strongly, evenly arcuate. Legs black; base of tibiae dark brown; all tibiae with apical spurs. First segment of hind tarsus only slightly longer than second and third together; not so long as second, third, and last together; a little less than one-third length of tibia. Tarsal claws appendiculate. Aedeagus symmetrical, acutely pointed at apex; orifice not covered with a sclerotized plate; nearly straight in lateral view.

Length 3.5 mm.; width 1.5 mm. across humeri.

Holotype. Male, Uvalde, Texas, D. J. and J. N. Knull (OSU).

This species is similar in form to *P. lecontii*. It differs in having testaceous head and pronotum and black legs. It is slightly smaller and more robust than *lecontii*, and the aedeagus is nearly straight in lateral view.

PSEUDOLUPERUS LECONTII (CROTCH)**Figures 59, 64**

Moderately elongate; sides of elytra parallel; elytra wider than pronotum. Head, pronotum, and underside black; elytra dark metallic blue or green; legs and antennae usually testaceous, may be dark.

Head black; labrum and clypeus brown. Surface alutaceous. Frontal tubercles swollen, delimited behind by a very deep interocular sulcus. Interantennal carina prominent, convex. Interocular distance two-thirds width of head across eyes; area behind eye pubescent. Antennae testaceous; intermediate segments slightly darker. Third segment nearly as long as fourth, nearly twice as long as second. Fourth through tenth equal in length. Antennae reach beyond middle of elytra.

Pronotum black; finely, closely punctate; shiny; length is five-sevenths of width. Lateral margins strongly sinuate, widest at apical third. Front angles swollen; hind angles produced, truncate. Scutellum black, broadly rounded. Each elytron three times longer than wide, convex. Surface strongly alutaceous; very finely punctate; finely, sparsely pubescent. Epipleura wide at base, gradually becoming narrower, evident to apex.

Ventral surface of body black, rather closely pubescent. Prosternum extends narrowly between front coxae; front coxal cavities open. Legs usually entirely testaceous, rarely with femora and hind tibiae black. All tibiae, in both male and female, with apical spurs. Tarsal claws appendiculate. First segment of hind tarsus longer than second and third together but not so long as second, third, and last together; slightly less than one-third the length of tibia.

Male. Last ventral abdominal segment with apex at middle truncate, depressed, without lobe. Aedeagus narrow, gradually narrowing to acute point, symmetrical; orifice without sclerotized plate. From lateral view aedeagus looks bent in middle, apical half strongly arcuate.

Length 4.5 to 5 mm., width 2 to 2.2 mm.

Specimens examined. BRITISH COLUMBIA: Copper Mtn. WASHINGTON: Shelton, July; Walla Walla, May; Toppenish, May. IDAHO: W. Springs, Aug. WYOMING: Stabler, July. NEW MEXICO: Santa Fe. SOUTH DAKOTA: 2, Black Hills (CARNEGIE-Ulke). ARIZONA: 1 ♂, 3 ♀♀, 2 mi. W Eagar, July 23, 1948, Werner, lush river bottom (U. ARIZ.); 2 ♀♀, Lakeside, July 1, 1939, R. Knox, on live scrub oak (U. ARIZ.)

This species seems to be fairly common west of the Rocky Mountains. It is rather constant in appearance, but a couple of erroneous

reports in the literature have caused some confusion in its identification. Horn estimated that the first segment of the hind tarsus is nearly half the length of the tibia and as long as the following segments together. This is an exaggeration which has resulted in the synonym *pallipes* being described more recently.

Schaeffer's variety *asclepiadis* is darker in color than typical *lecontii* but does not seem to differ otherwise. Consequently, this name is listed as a synonym of *lecontii*. The name is unfortunate in the first place. According to W. J. Brown, in personal correspondence, the host was recorded as *Asclepias* through a confusion of correctly determined plant specimens. The host in this case was *Apocynum androsaemifolium*. Beller and Hatch, 1932, recorded *Psoralea physodes* (Leguminosae) as host.

PSEUDOLUPERUS LINUS, NEW SPECIES

Figures 69, 70

Elongate oval; pronotum much narrower than elytra; head comparatively small. Prothorax entirely testaceous; each elytron testaceous with all margins and one median longitudinal stripe black. Rest of body and appendages black; head and abdomen with extremely faint blue luster.

Head normal in male. Eyes small; interocular distance about five-eighths width of head across eyes. Vertex impunctate. Ocular sulcus distinct, narrow, deep. Coronal suture indistinct. Interocular sulcus indicated by a large, deep, triangular, median depression and a large, round depression behind each tubercle in line with the antennal insertions. Frontal tubercles distinct; well delimited; moderately swollen; rectangular, with surface smooth, shiny; separated from orbit by a distinct groove. Orbit very narrow, distinctly delimited. Longitudinal frontal carina prominent, moderately swollen, extending between tubercles, more or less confluent with the tubercles. Transverse frontal carina moderately declivous in front. Antennae normal in male, reaching to middle of elytra. Antennal segment 3 as long as 2; segment 4 longer than 3 but not so long as 2 and 3 together. Prothorax with narrow, lateral, marginal bead. Pronotal width is one and one-half times length. Pronotum slightly narrower at apex than at base; widest at apical third; sides evenly, moderately arcuate. Hairs forming a fringe on basal and apical margins, a few on sides also. Surface of pronotum even, moderately convex; disc flattened; surface without distinct depressions; glabrous; impunctate. Elytra half again as wide as pronotum at base, with sides nearly parallel,

Humeri prominent, with distinct sulcus between humerus and disc. Surface of elytra moderately convex, without carinae, confusedly punctate with extremely fine punctures, smooth, shiny, not alutaceous, with a few scattered hairs, at least on apical half.

Mandibles with teeth 2 and 3 normal; tooth 1 is very small. Epipleuron moderately broad at base, gradually becoming narrower, narrow but distinct at apical angle. Prosternum not extending between front coxae; front coxal cavities open. Legs normal in male; apical spurs on all male tibiae. Basitarsi normal, not swollen; that of hind leg about as long as segments 2 and 3 together. Tarsal claws appendiculate. Last ventral abdominal segment of male broadly flattened at middle, with a median apical rectangular lobe whose width is three times its length. Aedeagus with basal lateral lobes which approach spurs in appearance; apex pointed, more or less symmetrical; orifice symmetrical, not covered by a sclerotized plate.

Length 4.5 mm.; width across humeri 1.7 mm.

Holotype, ♂, Chisos Mts., Tex., VI-23-61, D. J. & J. N. Knull, No. 805 (OSU).

This small species is similar to *Synetocephalus bivittatus* in general appearance but has dark, lateral, elytral margins and a single median stripe. *Synetocephalus adenostomatus* also has dark elytral margins but lacks a median elytral stripe. In the form of the aedeagus and prosternum, this species is very similar to *Pseudoluperus fulgidus* and apparently is most closely related to it.

PSEUDOLUPERUS LONGULUS (LECONTE)

Figures 48, 49, 50

Elongate; sides of elytra parallel; pronotum narrower than elytra. Entirely dark brown or black, may have faint blue luster.

Head impunctate, shiny, dark brown; frontal tubercles, clypeus, and labrum slightly lighter brown. Tubercles swollen; delimited behind by the deep interocular sulcus which terminates each side in a deep circular depression; delimited laterally by a broad depression running from the antennal insertions to the circular depression. Interantennal carina narrow, not strongly developed, separated from antennal insertions by a flat alutaceous area. Interantennal carina, interocular sulcus, and an area behind each eye with rather long hairs. Eyes with a few short erect hairs. Interocular distance slightly more than half width of head across eyes.

Antennae slender, reaching beyond middle of elytra. Fourth segment half again as long as second, third intermediate in length.

Fifth through tenth segments approximately same length as fourth. Basal segments testaceous, gradually becoming darker toward apex.

Pronotum slightly wider than long, widest at apical third; sides arcuate. Margins beset with erect hairs. Surface finely, moderately punctate, moderately convex. Anterior angles rounded, not swollen; posterior angles rectangular. Scutellum evenly rounded behind, surface alutaceous.

Length of each elytron over four times width. Surface moderately convex, alutaceous, sparsely pubescent. Punctures obsolete, broad, very shallow. Epipleura narrow, reaching apical angles.

Ventral surface, except prosternum, densely pubescent. Prosternum extending narrowly between front coxae; front coxal cavities open. Mesosternum extending narrowly between middle coxae. Abdomen dark brown; apical half of each ventral segment darker. Fifth abdominal segment of male with a short, rectangular lobe at apex. Lobe and semicircular area just in front of it depressed; fifth segment broadly, transversely depressed; surface alutaceous, shiny. Fifth ventral abdominal segment of female evenly, narrowly rounded. Legs dark brown. Front and middle tibiae and tarsi paler, testaceous. Apical spurs lacking on all tibiae of both male and female. Tarsal claws appendiculate. First segment of posterior tarsus a little less than length of second and third together, and a little less than one-third the length of tibia.

Aedeagus symmetrical, flattened, widest at middle, more or less gradually tapering to an acute point. Apex more or less bent downward. Orifice not covered by a sclerotized plate.

Length 3.2 to 4.8 mm.; width 1.5 to 1.6 mm.

Type. The type of *longulus* is in the Leconte collection (MCZ). The male type of *Pseudoluperus bakeri* Beller & Hatch in the University of Washington collection, Seattle, is from Sunrise, Mt. Ranier, Washington, 19 Aug. 1931, Wm. W. Baker.

Other specimens examined. CALIFORNIA: 8 ♂♂, 13 ♀♀, Cisco, VIII-1-20, Ricksecke (CAS, W); 1 ♀, Warner Mts., Modoc Co., VII-10-1919 (CAS). OREGON: 27 ♀♀, nr. Burns, VI-4-1938 (CAS). WASHINGTON: 1 ♂, Sunrise Pk., Ranier N. Pk., VII-24-36, E. C. VanDyke (CAS). NEVADA: 2 ♀♀, Carson City, June 25, 1925 (CAS); 1 ♂, Verdi, V-31-31 (CAS). UTAH: 7 ♀♀, Salt Lake City, June 1926, E. C. Van Dyke (CAS); 45 ♀♀, Ft. Douglas, June 7-15, E. C. VanDyke (CAS); 1 ♂, Harley Dome, May 29, 1950, Werner (U. ARIZ.); 1 ♂, Stockton, June (W). WYOMING: 2 ♀♀, Como (NYSM). COLORADO: 5 ♂♂, 16 ♀♀, Paonia, Delta Co., June 14, 1926, E. C. VanDyke (CAS,

NYSM), 7, Laramie Co. (CARNEGIE). NEBRASKA: 3 ♂♂, (CARNEGIE).

The type of *Pseudoluperus bakeri* has been reexamined and dissected. It is so nearly identical with the type of *Luperus longulus* that there is no doubt that they represent the same species. This species is quite variable in form and in the intensity of the dark pigment in the integument. Variation in form of the aedeagus is indicated in the illustrations. Possibly more than one species or subspecies is involved, but more and better series will have to be obtained to settle that question.

PSEUDOLUPERUS MACULICOLLIS (LECONTE)

Figures 61, 68

Black or dark brown; elytra dark metallic blue, green, purple, or bronze. In some specimens the pronotum is pale with darker median spot. Apical spurs lacking on all tibiae of male and female. Last ventral abdominal segment of male with a semicircular, depressed area at apex. A very short, depressed, pubescent, rectangular lobe within this area.

This species is very similar to *cyanellus* (Horn). It differs from that species in having rather coarse, confluent, elytral punctation; the aedeagus is a little more sinuate, with apex gradually tapering to tip; and in its larger size, 5.3 to 7 mm. long.

PSEUDOLUPERUS SPRETUS (HORN)

Horn, 1893, described this species as follows: "Oblong-oval, black, shining, four basal joints in the antennae and the legs (except femora at base) yellow. Antennae three-fourths the length of the body, second joint small, nodiform, scarcely half the third, these two as long as the fourth. Head smooth, transverse impression straight, entire. Thorax one-third wider than long, widest in front of middle, sides feebly arcuate, hind angles not prominent, disc convex, smooth, a few very fine punctures near the front angles. Elytra shining, sparsely, finely punctate; prosternum narrowly prolonged between the coxae. Legs entirely yellow, except the bases of the femora. Length 4 mm. The first joint of the hind tarsus is one-third the length of the tibia, and scarcely as long as the following joints together."

The type No. 3808, in the Horn collection, Philadelphia Academy of Science, is a female from Texas. No other specimens of this species have been recognized. This species is very similar to *texanus* (Horn) and may even belong to the same species. It is also similar in appear-

ance to *P. longulus* (Leconte), but spurs could be seen on the front and middle tibiae. The apices of the hind tibiae were hidden but probably also have apical spurs. Compared with *longulus*, it is more distinctly punctate on the pronotum; the pronotum is a little narrower and more convex; the frontal tubercles are quite flat but delimited from interantennal carina by narrow but deep grooves.

PSEUDOLUPERUS TEXANUS (HORN)

Horn, 1893, described this species as follows: "Form oblong, parallel, black, thorax and legs (except bases of femora) yellow. Antennae two-thirds the length of the body, brown, the basal five joints pale, joint two small, nodiform, third three-fourths the length of the fourth. Head smooth, transverse impression straight, entire. Thorax one-third wider than long, widest in front of middle, not narrower in front, sides arcuate, hind angles not prominent, disc smooth. Elytra twice as long as wide, sides very feebly arcuate, disc sparsely, but distinctly punctate, nearly smooth at apex, surface shining. Body beneath black, prosternum piceous, not at all prolonged between the coxae. Legs yellow, the bases of the femora piceous, but less on the anterior pair. Length 4 mm. Female—last ventral acutely oval at tip. The first joint of the hind tarsus is scarcely more than a fourth of the length of the tibia, and not as long as the following joints together."

The type No. 3804, in the Horn collection, Philadelphia Academy of Science, is a female from Texas. No other specimen of this species has been recognized. This is very similar to *spretus* Horn and may even belong to the same species. There are spurs on front and mid-tibiae; but none could be seen on the hind tibiae, although they may have been hidden because of the position in which the legs were folded. Compared with *P. longulus* (Leconte), the pronotum is broader and more convex. Tubercles are as in *spretus* with a deep groove behind them.

PSEUDOLUPERUS TUBERCULATUS (BLAKE)

Figures 71, 72

Mrs. Blake described *Luperodes tuberculatus* as follows: "About 4 mm. in length, oblong oval, faintly shining, yellow-brown, with narrow sutural and lateral piceous vittae on the elytra. In male a pair of tubercles in the middle of the abdomen.

"Head shining, pale yellow-brown, smoothly rounded over the occiput, a transverse line above the tubercles extending from eye to

eye, interocular space over half the width of the head; a slight protuberance between the antennal bases. Antennae entirely pale, extending to the middle of the elytra, second and third joints about equal, fourth not so long as second and third together. Prothorax about a fourth wider than long, with arcuate sides, not very convex, surface shining, very finely punctate, entirely pale. Scutellum pale. Elytra oblong, smoothly rounded with small humeral prominences, shining, very finely punctate; pale yellow-brown, with the sutural edges piceous almost to the apex, and a narrow lateral vitta extending over the humerus nearly to the apex, these two joined by a dark edge about the base and scutellum. Body beneath entirely pale. In male a pair of tubercles in the middle of the abdomen. Anterior coxal cavities open, hind tibiae spurred (others not visible) [all spurred in both male and female]. First hind tarsal joint not quite so long as the remaining ones together. Length 4-4.5 mm.; width 1.8-2 mm.

"Type, male, and 3 paratypes (2 male, 1 female), the type and 1 male paratype in collection of the Los Angeles Museum; 2 paratypes in National Museum collection, USNM No. 55112.

"Type locality.—Camp Baldy, at the foot of Old Baldy Mount, San Antonio Mountains in San Bernardino County, Calif., collected June 17, 1916, by L. L. Muchmore.

"Remarks.—The outstanding peculiarity of this species is the presence of a pair of well-developed tubercles on the abdomen of the male. I have not seen these on any other American beetle, although they are known to occur in such genera of the Galerucinae as *Phyllobrotica* and *Hoplasoma* in Europe and Asia."

Abdominal tubercles do occur on *Luperus* (?) *flavofemoratus* from Guatemala and on several species of *Scelida* from Arizona and Central America. There is little indication of any close relationship between these species and *tuberculatus*. The latter is not very closely related to any other known species and is rather doubtfully included in *Pseudoluperus*.

PSEUDOLUPERUS WALLACEI, NEW SPECIES

Figure 67

Form elongate; sides of elytra parallel; pronotum distinctly narrower than elytra. Body and elytra very dark brown or black; elytra, pronotum, and vertex with more or less distinct greenish bronze luster; femora black; tibiae and tarsi light brown; antennae dark brown; basal two or three segments pale brown. Antennae of male normal.

Vertex very finely, sparsely punctate; surface between punctures smooth, shiny. Ocular and coronal sulci not visible. Interocular sulcus very shallow, broad. Tubercles indistinct, very slightly swollen, with surface smooth, shiny, confluent with orbit on each side, not separated from each other, separated from interantennal carina by a very faint, shallow impression. Interantennal carina broad, nearly flat, finely punctate. Antennal insertions separated from each other by a distance equal to two and one-half times distance from insertion to eye. Antenna rather short, not reaching much beyond humerus. Antennal segment 3 about one and one-half times as long as 2, segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum wider than long, width equal to 1.4 times length; wider at apex than at base, widest at apical third; sides moderately arcuate; base evenly, moderately arcuate. Anterior angles somewhat swollen; posterior angles obtuse. Pronotum moderately convex; with very faint, broad depressions on each side; finely punctate; surface between punctures smooth, shiny. Scutellum brown, distinctly paler than elytra. Elytra one-fifth wider than pronotum at base; sides nearly straight. Length of each elytron four times width. Humeri moderately prominent, with a shallow depression between the humerus and disc. Surface of elytra moderately, evenly convex; very finely punctate; surface somewhat rugose; shiny, not alutaceous; with a few scattered, erect hairs near apex.

Epipleura moderately broad at base, becoming gradually narrower, very narrow but distinct at apical angle. Prosternum narrowly separating front coxae; front coxal cavities open. Male with legs normal, apical spurs on all tibiae. First segment of front and middle tarsi swollen. First segment of hind tarsus almost but not quite so long as the following two segments together. Claws broadly appendiculate. Last ventral abdominal segment of male somewhat flattened at middle, with a short broad apical lobe.

Aedeagus with basal lateral lobes which approach spurs in appearance. Apex rounded or somewhat truncate in type (there is a possibility that in this specimen the tip may have been broken and lost). Apex and orifice symmetrical; orifice not covered with a sclerotized plate. In lateral view the organ is moderately, regularly convex, curved downward.

Length 3.2 mm.; width 1.2 mm. across humeri.

Holotype. A male, Wild's Ranch, Hill Creek, Uintah Co., Utah, elevation 6,000 ft., Aug. 5 and 6, 1937, G. E. Wallace, Carnegie Mus. Acc. 11394, field notes No. 22 (No. 503) (CARNEGIE).

This small species seems to be more closely related to *P. wickhami* than to any other species known. The dark pronotum and small size will easily identify it.

PSEUDOLUPERUS WICKHAMI (HORN)

Figure 66

Small, 3.5 mm. Elongate; elytra parallel; pronotum three-fourths width of elytra at base. Black or dark brown; prothorax yellow; front, antennae, tibiae, tarsi, and apex of each femur light brown.

Head shining black or dark brown; tubercles and face below antennae lighter brown. Vertex very finely, very sparsely punctate. Interocular sulcus indistinct, indicated by three deep, round depressions—one median and one each side. Tubercles not distinctly separated from each other nor from the interantennal carina, which is wide and moderately convex. Eyes small; interantennal distance a little more than half the width of head across eyes. Antennae slender, reaching middle of elytra; third segment very little longer than second; segments 2 and 3 together half again as long as 4; segments 4 through 10 same length.

Pronotum yellow, widest at apical fourth, narrowest at base; sides moderately arcuate. Front angles nodiform; basal angles small, obtuse; lateral margin narrow. Base evenly arcuate. Surface of pronotum smooth, shining, impunctate; moderately, evenly convex. Scutellum dark, smooth, shining. Elytra black or very dark brown, with very faint blue luster; length of each elytron nearly four times width. Surface shining, faintly rugose, punctures fine, irregularly placed; a few scattered, erect hairs on apical half. Margin narrow; epipleura moderate, becoming narrow just before middle, reaching apical angles.

Prosternum extending narrowly between coxae; front coxal cavities open. Metasternum smooth; very finely, sparsely punctate; sparsely pubescent. Coxae, base, and apex of each femur, tibiae, and tarsi light brown. All tibiae of male with small apical spurs. Tarsal claws appendiculate. First segment of posterior tarsus one-fourth length of tibia, not quite so long as second and third together.

Male. Tarsi and antennae similar to female, not modified. Last ventral abdominal segment with a small semicircular, depressed, apical lobe, which is one-fourth length of segment. Base of lobe with two comparatively large, circular depressions. Aedeagus symmetrical, pointed, without sclerotized orificial plate; moderately arcuate; with acute ventral median ridge in apical half.

Length 3.5 mm.; width 1.25 mm.

Type. The male lectotype, No. 3807 in the Horn collection in Philadelphia, is labeled merely "5950" and "22."

Other specimens examined. ARIZONA: 1 ♂, Peach Springs, 8/2 (MCZ-Fall); 1 ♂, Peach Springs, Wickham (USNM); 1 ♂, Br't. Angel, 10-7, Barber & Schwarz (USNM); 3 ♂♂, Grand Cn., July 26, 1926, E. C. VanDyke (CAS).

In general appearance, this small species is quite similar to *Scelolyperus torquatus*, but the form of the aedeagus and last ventral abdominal segment of the male is vastly different.

A male specimen from "Br't Angel," Arizona, in the USNM is very pale, yellow-brown with head, lateral margins of elytra and a broad, sutural spot somewhat darker brown. Otherwise, the specimen is typical for the species. The aedeagus is identical with that of the type. There is an extremely faint greenish luster on the elytra.

GENUS SYNETOCEPHALUS FALL

Moderately elongate; sides of elytra parallel. Color usually yellow or testaceous, often with black elytral stripes. Length 3 to 6 mm. Eyes small or moderate, interocular distance more than half the width of head across eyes. Front feebly convex. Frontal tubercles flat, very feebly delimited behind. Interantennal carina very wide and flat. Antennae slender; second and third segments nearly equal; fourth much longer, may be longer than segments 2 and 3 together. Pronotum evenly, moderately convex, one-half wider than long; lateral margins evenly arcuate or only slightly sinuate; sides of elytra parallel, one-third wider than pronotum, moderately convex. Length of each elytron three or four times width. Surface usually glabrous, may have a few scattered hairs in some species. Front coxae narrowly separated, cavities open. All tibiae, both male and female, with terminal spurs. First segment of hind tarsus a little longer than second and third together, not so long as all following segments together, one-third length of tibia. Tarsal claws broadly lobed.

Last ventral abdominal segment of female evenly, narrowly rounded. Last ventral abdominal segment of male with a short, broad, deflected median apical lobe and a broad, median, semicircular depression on apical two-thirds of segment.

Aedeagus bilaterally symmetrical with orificial plate, except in *crassicornis*. Orificial plate in part sclerotized and with apical angles acute, rectangular, or rounded.

The following species are transferred to *Synetocephalus*: *Luperodes bivittatus* (Leconte), *L. diegensis* Blake, *L. monorhabdus* Blake, *L.*

atricornis Fall, *L. curvatus* Fall, *L. crassicornis* Fall, *vandykei* Blake, and *adenostomatus* White. They form a group best defined by the characters of the aedeagus and the comparatively broad head with small eyes.

Synetocephalus Fall

Synetocephalus Fall, 1910, Trans. American Ent. Soc. 36:146.

Type: *Synetocephalus autumnalis* Fall, 1910, by monotypy.

Synetocephala Fall, Weise, 1924, Coleop. Cat., pars 78, p. 49 (error).

adenostomatus (White) Calif.

Luperodes adenostomata White, 1942, Bull. Brooklyn Ent. Soc. 37:31.

atricornis (Fall) Calif.

Luperodes atricornis Fall, 1910, Trans. American Ent. Soc. 36:149.

autumnalis Fall Calif.

Synetocephalus autumnalis Fall, 1910, Trans. American Ent. Soc. 36:146.

bivittatus (Leconte) Calif., Oreg.

Phyllobrotica bivittata Leconte, 1859, Proc. Acad. Nat. Sci. Philadelphia 11:81.

Luperus bivittatus (Leconte), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:209.

Luperodes bivittatus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:110.—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 59, fig.

crassicornis (Fall) Calif.

Luperodes crassicornis Fall, 1910, Trans. American Ent. Soc. 36: 151.—Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):59, fig.

curvatus (Fall) Calif.

Luperodes curvatus Fall, 1910, Trans. American Ent. Soc. 36:150. —Blake, 1942, Proc. U.S. Nat. Mus. 92(3139): 59, fig.

diegensis (Blake) Calif.

Luperodes diegensis Blake, 1942, Proc. U. S. Nat. Mus. 92(3139): 60, fig.

monorhabdus (Blake) Calif., Nev.

Luperodes monorhabdus Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):60, fig.

vandykei (Blake) Calif.

Luperodes vandykei Blake, 1942, Proc. U.S. Nat. Mus., 92(3139): 73, fig.

- orificial plate at apex (figure 76); 4.3-5 mm. long;
 Calif. *bivittatus* (Leconte)
 Aedeagus not narrower at apical fourth; distance from
 orificial plate to apex of aedeagus about equal to
 width of orificial plate at apex; 4.2-5.8 mm. long;
 Calif. *diegensis* (Blake)

SYNETOCEPHALUS ADENOSTOMATUS (WHITE)

Figures 80, 81

Body elongate; sides of elytra parallel; elytra wider than prothorax. Upper surface black or dark brown; disc or discal stripe on each elytron pale, base and apex dark; pronotum brown, paler in median anterior third.

Head dark; tubercles and front lighter brown. Vertex and front impunctate, smooth, and shining. Frontal tubercles broad, shallow. Interocular sulcus does not extend laterally beyond tubercles. Head without sulcus between tubercles and orbit. Frons between antennae flat, somewhat carinate below antennal sockets. Antennae widely separated; distance between them three times distance from eye to base of antennae. Clypeus truncate.

Antennae reach apical fourth of elytra in male, a little past middle in female. Second and third segments equal; segments 2 and 3 together equal to fourth in male, a little longer than fourth in female. Terminal segment but little longer than penultimate and with apical lobe rounded.

Pronotum one-fourth wider than long, widest at apical third, strongly arcuate to apical angles which are obtuse; surface shining, finely, closely punctate; usually without impressions but in one female with a small, deep depression on each side behind middle. Scutellum dark, impunctate, strongly polished. Elytra strongly shining, the pale vittae alutaceous, with shallow, obsolete punctures, epipleura dark.

Legs and body beneath dark; abdomen in female yellow. Apical spurs on all tibiae of both male and female. Posterior basitarsi longer than second and third segments together. Tarsal claws appendiculate. Front coxal cavities open. Prosternum extending narrowly between coxae.

Aedeagus symmetrical, apex gradually tapering to a point; orifice at apical third covered by a broad, truncate, sclerotized plate. Aedeagus, in lateral view, slightly arcuate downward; tip deflexed, without basal spurs.

Length of male 2.8 to 3.2 mm.; of female 3.4 to 3.5 mm.

This species resembles *bivittatus* but is smaller, and the epipleura and lateral elytral margins are dark. The aedeagus differs from that of other members of the genus in having a uniformly sclerotized orificial plate.

The description above was drawn partly from the original description and partly from a pair of paratypes in the USNM (Sunset Valley, Santa Barbara County, California, VII-4-1939, on *Adenostoma fasciculatum*, B. E. White). *Adenostoma* is in the Rosaceae.

SYNETOCEPHALUS ATRICORNIS (FALL)

Figure 75

Fall described *Luperodes atricornis* as follows: "Oblong, moderately elongate, head brown, prothorax entirely yellow, antennae, legs and metasternum black, abdomen paler. Upper surface polished throughout, the head with a few fine punctures posteriorly, prothorax scarcely visibly punctulate, elytra finely, rather closely punctate. Antennae fully two-thirds as long as the body, second joint a trifle longer than the third, the two together as long as the fourth. Front broadly convex, not at all carinate between the antennae. Prothorax nearly one-half wider than long, widest at middle, sides arcuate, minutely sinuate at the hind angles. Elytra parallel, barely two-fifths wider than the prothorax, three and one-third times as long and about two-thirds wider than the prothorax. Basal joint of hind tarsus very little longer than the next two. Length, 4.4 mm.; width, 2.25 mm.

"Described from a single specimen taken by the late Prof. Snow in the Santa Rita Mountains, Arizona (8000 feet).

"The type is a male having the last ventral truncate at middle and with two very short longitudinal incisions delimiting a sub-rectangular median lobe, which is moderately deeply impressed, the impression extending forward to the middle of the segment. By Horn's table this species will fall near *atriceps*, which, according to description, has the head black, the upper surface subopaque and more distinctly punctate, and the basal joint of hind tarsus much longer."

Synetocephalus atricornis (Fall) very closely resembles *S. monorhabdus* (Blake) and may be identified with certainty only by the characters of the aedeagus described in the key. While *S. monorhabdus* usually is vittate and often has a dark pronotal spot, specimens from Nevada may be entirely pale above.

SYNETOCEPHALUS AUTUMNALIS FALL**Figures 73, 74**

Fall, 1910, described this species as follows: "Elongate, parallel, testaceous, occiput, basal margin of elytra, epipleura and episterna suffused with reddish, tip of last antennal joint blackish; upper surface densely rather coarsely subrugosely punctate. Head large, front feebly convex and nearly smooth between the antennae; frontal tubercles flat, limited behind by impressed lines, vertex and occiput densely punctate. Antennae very slender, first joint as long as the next two, second and third subequal, together not quite as long as the fourth, fourth to eleventh subequal, nearly linear, each about five times as long as wide. Prothorax not quite as wide as the head, one-half wider than long, widest at apical third, or two-fifths, base broadly arcuate, scarcely as wide as apex, the latter squarely truncate, all the angles minutely prominent. Elytra parallel, one-third wider than, and more than three times as long as the prothorax, and nearly twice as long as wide. Beneath shining, sparsely pubescent, obsoletely sparsely punctulate. Length 4-4.3 mm.; width 1.6-1.9 mm.

"The above description applies to the male, the only female at hand differing in having the head not wider than the prothorax, and in entirely lacking the reddish tint present on certain parts of the body in the male. In the latter sex the last ventral is rather broadly deeply impressed in apical half, the impression narrowing in front, and the basal joint of the front and middle tarsi is parallel sided instead of narrowed basally as in the female. These basal joints though obviously feebly dilated are still very slender, being about four times as long as wide."

Fall described the species from specimens collected by Dr. Fenyès from the Sierra Madre Mountains near Pasadena, California, September.

SYNETOCEPHALUS BIVITTATUS (LECONTE)**Figure 76**

Mrs. Blake described the type of *bivittatus* (Leconte) as follows: "The type specimen, a male, is pale yellow, with a narrow sutural and moderately wide lateral vitta extending from the base over the humerus but not reaching the apex. The head is polished, impunctate, rounded, a deeper yellow than the prothorax, with the mouthparts having darker tips. The interocular space is more than half the width of the head. The antennae are pale, not extending to the middle of the elytra, the fourth joint nearly twice as long as the third. The

prothorax is widest before the middle, is a third wider than long with a faint suggestion of spotting, and is polished and nearly impunctate. The scutellum is pale. The dark elytral vittae are joined about the base with a narrow dark line. The elytra are not very distinctly punctate. The body beneath is pale, the breast slightly deeper yellow-brown in coloring. The anterior coxal cavities are open."

There is some variation in the width of the dark elytral stripes, and in some specimens the underside is in large part dark. The aedeagus (figure 76) differs from closely related species in being narrowed just before the apex; also, the sclerotized orificial plate is comparatively longer than in other species.

S. bivittatus is very similar to *S. diegensis* (Blake) and *S. monorhabdus* (Blake) and can be identified with certainty only by characters of the aedeagus.

Synetocephalus bivittatus (Leconte) seems to be fairly common in central and northern California and southern Oregon.

SYNETOCEPHALUS CRASSICORNIS (FALL)

Figure 78

Fall described *Lupeodes crassicornis* as follows: "Oblong ovate, flavotestaceous, prothorax a little darker, head rufotestaceous to piceous, antennae and legs pale, the femora darker. Antennae not much longer than half the body, stout, joints 2-3 subequal, together fully as long as joint 4. In the male joint 3 is triangular and fully as wide as long, 4-10 triangular or subtriangular, 4 about one-half longer than wide. In the female the antennae are less stout, joint 3 more oval and evidently longer than wide, the outer joints subtriangular and rather less than twice as long as wide. Upper surface throughout polished and very finely remotely punctulate. Tibiae straight in both sexes. Basal joint of hind tarsus barely as long as the next two. Length, 3 mm.; width, 1.5 mm.

"Mojave, California. June 1st. One ♂, three ♀s, taken by Dr. Fenyes.

"The last ventral of the ♂ is broadly triangularly impressed for the greater part of its length, truncate at middle posteriorly, with a minute incision on each side; the basal joint of front and middle tarsi not appreciably dilated. *Crassicornis* closely mimics *curvatus*, especially the females, which but for the distinctly stouter and shorter antennae of the former would be practically indistinguishable. In *curvatus* the antennae are two-thirds as long as the body, the outer joints slender and fully three times as long as wide. The males are

more readily separable, the prothorax being less broad in *crassicornis*, and the antennae and tibiae very different."

SYNETOCEPHALUS CURVATUS (FALL)

Figure 77

Fall described *Luperodes curvatus* as follows: "Oblong oval, pale yellow above, head brownish, antennae entirely pale, body beneath brownish or piceous, legs pale, the femora more or less brown. Upper surface highly polished and subimpunctate throughout, the punctures very fine, sparse and feebly impressed. Joints 2-3 of antennae subequal, together fully as long as the fourth. Front obtusely convex between the antennae, impressed above the flattened tubercles. Prothorax rather large, moderately transverse, sides rounded and a little narrowed behind. Elytra one-third wider than the prothorax and a little more than two-fifths longer than wide. Basal joint of hind tarsus not longer than the two following. Length 3 mm.; width 1.7 mm.

"Bishop, California. A single pair collected and kindly given me by Dr. Fenyès.

"In the male the tibiae are all curved at base, the basal joint of the front and middle tarsi is slightly dilated and the last ventral has an impressed median lobe, formed nearly as in the preceding species [*atricornis* Fall]. In the female the tibiae are straight, the basal joint of the four anterior tarsi more slender basally, and the last ventral is of the usual form for this sex. The color, relatively broad prothorax, nearly impunctate upper surface and curved male tibiae easily distinguish this species from any other known to me."

The curvature of the male tibiae is very slight and not much more obvious than in related species. The long slender tip of the aedeagus and broadly curved orificial plate are quite distinctive.

SYNETOCEPHALUS DIEGENSIS (BLAKE)

Mrs. Blake described *Luperodes diegensis* as follows: "About 4-5.5 mm. in length, elongate oblong, shining pale yellowish with narrow dark elytral vittae at suture and from the humerus nearly to the apex, body beneath dark, last four or five antennal joints tending to be slightly paler than basal ones.

"Head polished, deeper reddish yellow in coloring, smoothly rounded over the occiput, frontal tubercles well defined, interocular space very wide, over half the width of the head. Antennae extending nearly to the middle of the elytra, third joint shorter than fourth; in

color varying from pale to reddish brown, but in darker specimens the four or five apical joints becoming paler than the basal ones. Prothorax about a third wider than long, somewhat convex, with rounded sides, shining, finely alutaceous, usually deeper reddish yellow than elytra. Scutellum usually dark. Elytra oblong, somewhat convex, elytral humeri not prominent, only faint trace of intrahumeral depression, finely punctate; pale yellow with sutural edges piceous nearly to apex, and a narrow lateral vitta extending over the humerus nearly to the apex. Body beneath usually dark with pale pubescence, legs pale, all tibiae spurred, first tarsal joint of hind leg barely as long as the remainder together. Anterior coxal cavities open. Length 4.2-5.8 mm., width 1.9-2.5 mm.

"Type, male, and 6 paratypes (5 female, 1 male), U.S.N.M. No. 55110.

"Type locality.—San Diego, Calif., collected January 1, 1909, by Ricksecker on the flowers of *Adenostoma*.

"Other localities.—Pinon Flat, San Jacinto Mountains, collected by E. S. Ross; in the mountains near Claremont, collected by C. F. Baker.

"Remarks.—This species, confused in collections with *S. bivittatus* (Leconte), seems to occur only in southern California. It is more convex than *bivittatus*, and the aedeagus is different."

SYNETOCEPHALUS MONORHABDUS (BLAKE)

Mrs. Blake described *Luperodes monorhabdus* as follows: "About 4.5 mm. in length, elongate oblong, moderately shining, yellow-brown, with reddish-brown antennae and usually a median spot or vitta on the pronotum, and on the elytra a sutural and a lateral vitta, the body beneath tending to be dark.

"Head polished, pale, with the tips of the mouth parts slightly deeper in coloring, rounded and polished over the occiput, tubercles well defined, with a transverse depression above, interocular space over half the width of the head. Antennae reaching scarcely to the middle of the elytra, third joint not so long as fourth, all joints deep reddish brown or darker. Prothorax somewhat convex with rounded sides, scarcely a third wider than long, polished, very finely punctate, deep yellow or reddish and usually with a dark median vitta, but this sometimes lacking. Scutellum dark. Elytra oblong, somewhat convex, with moderately prominent humeri and short intrahumeral depression, shining, very finely punctate; pale, a dark sutural vitta not reaching the apex, and a lateral one extending over the humerus and about the scutellum to join the sutural one. Body beneath dark,

shining, with a pale pubescence; anterior coxal cavities open. Legs pale, each tibia spurred, first hind tarsal joint not so long as the rest together. Length 4.2-4.9 mm., width 1.8-2 mm.

Type, male, and 2 paratypes (female), U.S.N.M. No. 55111.

Type locality.—Los Angeles, Calif., collected by Coquillett.

Remarks.—The uniform color of the dark antennae, in which neither basal nor apical joints are paler, and the dark vitta that is usually present on the pronotum differentiate this species from the other vittate ones. Two specimens in the Los Angeles Museum are labeled Los Angeles County, collected by M. Albright and 'Cal.' respectively."

SYNETOCEPHALUS VANDYKEI (BLAKE)

Figures 79, 82

Moderately elongate; elytra parallel; sides of pronotum strongly arcuate; angles small, obtuse; entirely testaceous; head and underside a little darker brown.

Head light brown, smooth, shining. Vertex very sparsely finely punctate, a large circular depression above each eye. Eyes small; interocular distance two-thirds width of head across eyes. Interocular sulcus impressed only in middle half of interocular space. Frontal tubercles and interantennal carina flat, not separated by sulci. Antennae reach middle of elytra; second and third segments equal; segments 2 and 3 together slightly longer than fourth; following segments about same length as fourth; color testaceous; apical segments a little darker.

Pronotal length is seven-tenths of the width. Pronotum widest a little before the middle; sides strongly arcuate; margin very narrow. Surface convex at sides; disc flat; each side with an indistinct callus just before middle. Surface of disc with irregular shallow depressions; punctuation very shallow, obsolete.

Scutellum triangular, smooth. Elytra half again as wide as pronotum at base; length is four times width; moderately convex. Surface faintly rugose, alutaceous; punctuation very fine; very sparse, short pubescence on apical half. Margin narrow; epipleura narrow, becoming very narrow at middle, reaching apex.

Abdomen, meso- and metasternum brown. Front coxal cavities open. Prosternum extending narrowly between coxae. Tibiae without longitudinal carinae. All tibiae with apical spurs. Tarsal claws appendiculate. First segment of hind tarsus as long as second and third together, one-third length of tibia.

Male. First segment of front and middle tarsi much broader than all of the following segments combined, about same width as tibia at apex. Apex of fifth ventral abdominal sclerite with a short, broad median lobe; apical half with depressed semicircular median depression. Aedeagus symmetrical, pointed; orificial plate strongly sclerotized with a single upturned point at apex; ventral surface flat.

Length 3.5, width 1.3 mm.

The type series (CAS) and a series in the Fall collection (MCZ) all came from Olancho, California, May-June 1917.

This small beetle is more nearly related to *Synetocephalus monorhabdus* (Blake) than to any other species known. It differs in being smaller, entirely pale testaceous above, more alutaceous, and in having a single apical point on the orificial plate of the aedeagus. In general appearance, it closely resembles some of the small *Calomicrus* species; however, the short hind tarsus and short apical abdominal lobe of the male cause it properly to be placed in *Synetocephalus*.

GENUS SCELOLYPERUS CROTCH

Elongate; elytral sides parallel; pronotum narrower than elytra. Head normal in male. Interocular sulcus deep; ocular sulcus distinct. Frontal tubercles strongly delimited behind, may or may not be confluent with orbit, separated from each other by a narrow sulcus, moderately convex. Supratentoria usually small, may or may not be distinct. Interantennal carina moderately prominent, narrow, extending more or less between the tubercles, separated from tubercles by a narrow sulcus. Antennae moderately slender, not modified; usually reaching about to middle of elytra; third segment usually a little longer than second; fourth usually longer than third but not so long as second and third segments together.

Pronotum a little wider than long; surface glabrous, moderately evenly convex, or rarely with a small impression on each side of middle. Scutellum dark brown or black, triangular, with apex rounded; surface more or less alutaceous. Elytra normal; in some species strongly carinate. Surface glabrous, usually with a few scattered, erect hairs on apical half; punctuation confused. Epipleura moderate in width at base, gradually narrowed, indistinct at apical fifth.

Prosternum extends narrowly between coxae; front coxal cavities open. Posterior tibiae of males may be straight or strongly curved. Apical spurs on all tibiae of females. In males, spurs may occur on all tibiae, only on front and middle tibiae, only on middle tibiae, or on none of the tibiae. All basitarsi may in some species be dilated, normal in others. Last ventral abdominal segment of female evenly

rounded at apex. Last ventral abdominal segment of male broadly flattened, truncate at apex; may have an extremely short, broad, strongly deflected apical lobe. Aedeagus with orifice symmetrical, not covered by a sclerotized plate; base without ventral spurs; apex may be symmetrical and truncate or emarginate, or it may be asymmetrically pointed or rounded. Surface of inner sac with two dorsal rows of cornuti; numerous smaller spines are scattered near apex of sac; flagellum very slightly sclerotized, short rounded, deflected.

The elytra are entirely black or metallic blue, green, or violet; legs and antennae and prothorax may be pale in some species.

Length 3 to 7 mm.

Range. So far known from nearly all parts of the United States and northern Mexico, also from southwestern Canada.

Luperus altaicus Mannerheim from the Altai Mountains, Siberia, belongs in this group of species and is hereby transferred to *Scelolyperus*. Undoubtedly there are other Eurasian species in this group, but time does not allow a thorough examination of them now.

The separation of typical *Scelolyperus* (*tejonicus* group) from the *meraca-varipes* group has previously been based on the presence or absence of apical tibial spurs. This character is difficult to see in many species, and Horn erred in failing to observe spurs on some of the specimens he examined, including the type species. There is a great deal of variation in this character in the genus as delimited above, and such variation may possibly occur within a species.

As now delimited, this genus contains a rather homogeneous group of species. The shape is quite uniform, and all species have dark head and elytra. Obvious differences between the species are to be found in size, color of pronotum, presence or absence of tibial spurs, sexual differences in the legs, abdomen, and in the external form of the aedeagus.

Many of the species which previously have been placed in *Scelolyperus* are now removed to other genera. Of these, *longulus* Leconte, *decipiens* Horn, *cyanellus* Horn, and *maculicollis* Leconte are transferred to *Pseudoluperus* Beller & Hatch. *S. flaviceps* Horn and nearly all of the neotropical species are transferred to *Scelida* Chapuis (see discussion under *Scelida*). The new genus *Keithatus* is provided for *S. blakeae* White.

W. H. Anderson, U.S. Department of Agriculture, has collected the only known immatures in this genus. They were found "in nearly red rotten oak (?) log beneath living oak tree and witch hazel bush, 21 or 27 March, 1938." The collection (USNM) contains a larva, cast skins, a pupa and adults determined correctly by H. S. Barber

as "*Luperodes meraca* (Say), L. 297." A label in the vial with the larva holds the comment, "no ocelli or pigment spots evident." A reexamination of the larva and pupa (figures 150-156) indicates that they are quite similar to those of *Diabrotica* and *Phyllobrotica*.

Scelolyperus Crotch

Scelolyperus Crotch, 1874, Trans. American Ent. Soc. 5:79. Type:

Scelolyperus tejonicus Crotch, 1874, by monotypy.

Horn, 1893, Trans. American Ent. Soc. 20:102.

bimarginatus (Blake)

N.C., Tenn.

Luperodes bimarginata Blake, 1928, Bull. Brooklyn Ent. Soc. 23:183.

carinatus, new species

Calif., Oreg.

chautauquus, new species

N.Y., Ga., Ark.

curvipes, new species

Calif.

cyanellus (Leconte)

N.C., Pa., Ohio

Luperus cyanellus Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:209.—Weise, 1924, Coleop. Cat., pars 78, p. 118.

Luperodes cyanellus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:116.—Wilcox, 1954, Ohio Biol. Surv., Bull. 43, p. 434.

flavicollis (Leconte)

Calif.

Phyllobrotica flavicollis Leconte, 1859, Proc. Acad. Nat. Sci. Philadelphia 11:81.

Luperus flavicollis (Leconte), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:209.

Scelolyperus flavicollis (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:104.—Weise, 1924, Coleop. Cat., pars 78, p. 108.

graptoderoides (Crotch)

Calif.

Luperus graptoderoides Crotch, 1874, Trans. American Ent. Soc. 5:80.

Scelolyperus graptoderoides (Crotch), Horn, 1893, Trans. American Ent. Soc. 20:105.—Weise, 1924, Coleop. Cat., pars 78, p. 108.

hatchi, new species

Wash.

laticeps (Horn)

Calif.

Luperodes laticeps Horn, 1893, Trans. American Ent. Soc. 20:114.

Luperus laticeps (Horn), Weise, 1924, Coleop. Cat., pars 78, p. 119.

liriophilus, new species

N.Y.

loripes Horn

Calif.

Scelolyperus loripes Horn, 1893, Trans. American Ent. Soc. 20:104.

megalurus, new species

Calif.

- meracus (Say) N.H., Ga., Kans.
Galleruca meraca Say, 1826, Jour. Acad. Nat. Sci. Philadelphia 5:299.
Luperus meraca (Say), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia 17:209.—Weise, 1924, Coleop. Cat., pars 78, p. 120.
Luperodes meraca (Say), Horn, 1893, Trans. American Ent. Soc. 20:115.—Wilcox, 1954, Ohio Biol. Surv., Bull. 42, p. 433.
- morrisoni (Jacoby) Ariz.
Luperus Morrisoni Jacoby, 1888, Biol. Centr.-Amer., Coleop. 6(1): 595.—Weise, 1924, Coleop. Cat., pars 78, p. 115.
Luperodes Morrisoni (Jacoby), Horn, 1893, Trans. American Ent. Soc. 20:117.
- nigrocyanus (Leconte) Colo.
Luperus nigrocyanus Leconte, 1879, Bull. U.S. G. & G. Surv. 5:517.—Weise, 1924, Coleop. Cat., pars 78, p. 121.
Scelolyperus nigrocyanus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:106 (synonym of *S. longulus*).
- nigrovirescens (Fall) Colo.
Luperodes nigrovirescens Fall, 1910, Trans. American Ent. Soc. 36:152.—Weise, 1924, Coleop. Cat., pars 78, p. 111.
- phenacus, new species Calif.
 phoxus, new species Calif.
 ratulus, new species Calif.
- schwarzi Horn Wash., Calif.
Scelolyperus Schwarzi Horn, 1893, Trans. American Ent. Soc. 20:105.
Luperus varipes: Beller and Hatch, 1932, Univ. Washington Publ. Biol. 1:114 (wrongly identified).
- smaragdinus (Leconte) Calif.
Luperus smaragdinus Leconte, 1859, Proc. Acad. Nat. Sci. Philadelphia 11:286.—Weise, 1924, Coleop. Cat., pars 78, p. 122.
Luperodes smaragdinus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:116.
- tejonicus Crotch Calif.
Scelolyperus tejonicus Crotch, 1874, Trans. American Ent. Soc. 20:104.—Horn, 1893, Trans. American Ent. Soc. 20:104.
- torquatus (Leconte) Calif.
Luperus torquatus Leconte, 1884, Trans. American Ent. Soc. 12:28.—Weise, 1924, Coleop. Cat., pars 78, p. 123.
Luperodes torquatus (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:115.

transitus (Horn)

Calif.

Luperodes transitus Horn, 1893, Trans. American Ent. Soc. 20: 113.

Luperus transitus (Horn), Weise, 1924, Coleop. Cat., pars 78, p. 123.

varipes (Leconte)

Mont., Calif., Wash.

Luperus varipes Leconte, 1857, preprint of 1860, Reports Expl. and Surv. for Railroad from Mississippi R. to Pacific Ocean, vol. 9, pt. 3, no. 1, p. 69.—Weise, 1924, Coleop. Cat., pars 78, p. 123.

Luperodes varipes (Leconte), Horn, 1893, Trans. American Ent. Soc. 20:118.

Luperus concavus Beller and Hatch, 1932, Univ. Washington Publ. Biol. 1:114. New synonymy.

Key to the species of *Scelolyperus* Crotch

- | | | |
|------|--|----|
| 1 | Pronotum pale | 2 |
| | Pronotum black, dark brown or metallic green, blue or purple | 15 |
| 2(1) | Length 4.7-7 mm. | 3 |
| | Length 3-4.7 mm. | 9 |
| 3(2) | Aedeagus pointed or rounded, asymmetrical; hind tibia of male straight | 4 |
| | Aedeagus broadly truncate, symmetrical; hind tibia of male may be strongly curved..... | 5 |
| 4(3) | Large, 6.5-7 mm. long; male tibiae without apical spurs; Calif. (figure 95) <i>flavicollis</i> (Leconte) | |
| | Small, 3-4.7 mm. long; male tibiae with apical spurs; Calif. (figure 96) <i>torquatus</i> (Leconte) | |
| 5(3) | Posterior tibia of male strongly curved with a prominent tooth on inner side at basal third (figure 86); last dorsal abdominal segment not produced; spurs on middle tibiae, none on front or hind tibiae; 5 mm. long; Calif. (figure 104) <i>tejonicus</i> Crotch | |
| | Posterior tibia without tooth | 6 |
| 6(5) | Last dorsal abdominal segment of male strongly produced (figure 88); hind tibia arcuate (figure 89); 4.7-6 mm. long; Calif. (figure 105) | |
| | <i>megalurus</i> , new species | |
| | Last dorsal abdominal segment not produced..... | 7 |
| 7(6) | Inner side of hind tibia with broad, glabrous, margined channel (figure 85); hind tibia strongly curved, without apical spurs; elytra dark blue, bluish green, or | |

- purple; pronotum black; apical and basal margins may be dark brown (variation in color indicates that specimens may occur with pale pronotum); 5.7-6mm. long; Calif. *curvipes*, new species
- Inner side of hind tibia evenly pubescent, without glabrous area; hind tibiae with apical spurs..... 8
- 8(7) Hind tibia arcuate in male; ventral side of apex of aedeagus with only two longitudinal carinae (figure 102); 5.5 mm. long; Calif..... *loripes* Horn
- Hind tibia of male nearly straight; ventral side of apex of aedeagus with four longitudinal carinae (figures 101, 103); 5 mm. long; Calif..... *ratulus*, new species
- 9(2) Elytral punctation moderate to rather coarse; punctures separated by a distance equal to twice their diameter or less 10
- Elytral punctation fine; punctures separated by a distance equal to three or four times their diameters 12
- 10(9) Male with hind tibiae strongly curved (figure 89) and last dorsal abdominal segment greatly produced (figure 88); elytra usually green, rarely blue-green; 4.7-6 mm. long; Calif. (figure 105)... *megalurus*, new species
- Male with hind tibiae straight and last dorsal abdominal segment normal 11
- 11(10) Aedeagus nearly straight in lateral view (figure 96), tip lateral, sides gradually narrowing to apex; elytra blue or green; 3.3-4.5 mm. long; Calif.
- torquatus* (Leconte)
- Aedeagus distinctly sinuate in lateral view (figure 98), somewhat spatulate in dorsal view, tip nearly central; elytra dark metallic blue, a little longer, more nearly parallel than in *torquatus*; 3.8 mm. long; Calif.
- phoxus*, new species
- 12(9) With a strong, lateral, submarginal elytral carina (figure 91); aedeagus symmetrical, apex gradually narrowed to acute tip (figure 152); 3.3-5.7 mm. long; Calif., Oreg..... *carinatus*, new species
- Without distinct elytral carina..... 13
- 13(12) Aedeagus not distinctly asymmetrical, truncate at apex, strongly sinuate in lateral view (figure 100); 3.4-3.8 mm. long; Calif. *phenacus*, new species
- Aedeagus distinctly asymmetrical at apex or not strongly sinuate in lateral view..... 14

- 14(13) Aedeagus spatulate, without acute or rectangular tip (figure 93); 3.3-4.2 mm. long; Calif. . . . *transitus* (Horn)
 Aedeagus not spatulate, the acute or rectangular tip far to the right; strongly sinuate in lateral view (figure 99); 3-3.7 mm. long; Calif. to Idaho. . . . *laticeps* (Horn)
- 15(1) Western species found west of the Great Plains (100° west longitude) 16
 Eastern species found east of the Great Plains (100° west longitude) 24
- 16(15) Elytra distinctly blue, green, or purple. 17
 Elytra black or dark brown without distinct blue, green, or purple luster 22
- 17(16) Hind tibia of male distinctly curved. 18
 Hind tibia of male straight or nearly so. 19
- 18(17) Hind tibia of male with a very broad, shallow, glabrous channel on inner side; margins of this channel distinct, explanate on ventral apical half (figure 85); pronotum without distinct blue, green, or purple luster; aedeagus widened at apex (figure 84), apex truncate, not emarginate; 5.7-6 mm. long; Calif.
curvipes, new species
 Glabrous inner area of hind tibia on male reduced or lacking, not margined; pronotum distinctly green or blue; aedeagus not widened at apex (figure 97), apex emarginate; 4.5 to 5.3 mm. long; Calif. to Wash. to Wyo. *schwarzi* Horn
- 19(17) Femora and tibiae entirely dark 20
 Femora and tibiae at least partly pale 21
- 20(19) Aedeagus with acute tip at apex (figure 94); all tibiae with spurs; 6 mm. long; Calif. . . . *smaragdinus* (Leconte)
 Aedeagus with rounded apex (figure 108); all tibiae lacking spurs; 7 mm. long; Calif.
graptoderoides (Crotch)
- 21(19) Aedeagus with strongly produced, twisted apical lobe (figure 107); 4.5-5 mm. long; Mont. to Calif. to Wash. *varipes* (Leconte)
 Aedeagus more evenly rounded at apex (figure 109); 4.5-5 mm. long; Ariz. *morrisoni* (Jacoby)
- 22(16) Elytra moderately punctate; punctures separated by a distance equal to two or three times their diameters; surface between punctures very finely punctulate, not alutaceous; apex of aedeagus strongly produced (fig-

- ure 113); 3.7 mm. long; Wash. to Calif. (figure 90) *hatchi*, new species
- Elytra finely punctate; punctures separated by a distance equal to three or four times their diameters; surface between punctures alutaceous; Colo. to Mont. 23
- 23(22) Aedeagus not narrowed behind apex or if narrowed, the constriction is near middle (figure 111); asymmetrical apical lobe much longer than in *nigrovirescens*; 3.3-3.5 mm. long; Colo. *nigrocyanus* (Leconte)
- Aedeagus slightly but distinctly narrowed at apical third; apex somewhat spatulate (figure 110); asymmetrical apical lobe much shorter than in *nigrocyanus*; 3-3.8 mm. long; Colo. to Mont.
- nigrovirescens* (Fall)
- 24(15) Prosternum between front coxae nearly as wide as second antennal segment (see *Altica*)
- Prosternum between coxae very thin, much narrower than second antennal segment 25
- 25(24) Elytra of female with an acute, submarginal carina; 4.3-4.8 mm. long; N.C. to Tenn. *bimarginatus* (Blake)
- Elytra without distinct, acute, submarginal carina 26
- 26(24) Apical half of aedeagus nearly twice as wide as basal half (figure 106); hind tibia of male without apical lamellate lobe; 4-5 mm. long; N.C. to Pa. to Ohio ("western states") *cyanellus* (Leconte)
- Apical half of aedeagus not, or little, wider than basal half; hind tibia usually with apical lamellate lobe in male 27
- 27(26) Aedeagus in dorsal view much narrower at middle, straight in lateral view (figure 117); 3.5-4 mm. long; N.Y. to Ohio to Tenn. *chautauquus*, new species
- Aedeagus about same width throughout 28
- 28(27) Aedeagus straight in lateral view (figure 116); legs usually entirely yellow; 4-4.5 mm. long; N.Y. on day lily (*Hemerocallis*) and ironwood (*Carpinus*)
- liriophilus*, new species
- Aedeagus feebly sinuate in lateral view (figure 114, 115); femora usually dark 29
- 29(28) Aedeagus in lateral view with basal half sinuate; apical half straight; 4.3-4.8 mm. long; N.C. to Tenn.
- bimarginatus* (Blake)

Aedeagus in lateral view with basal half straight; apical half sinuate; 4-4.7 mm. long; N.H. to Pa. to Ohio; on witch hazel (*Hamamelis*) and birch (*Betula*)
meracus (Say)

SCELOLYPERUS TEJONICUS CROTCH

Figures 86, 104

Crotch described *S. tejonicus* as follows:

"*Scelolyperus*. Agrees in all respects with *Luperus*, but the hind tibiae are deeply arcuate and furnished in their basal third with a strong triangular tooth. Body beneath and elytra steel-blue, base of antennae and thorax dark yellow; head smooth with a strong carina between the antennae; thorax rather broader than long, apparently impunctate, sides rounded in front, narrowed towards the base; scutellum black; impunctate; elytra steel-blue, rather coarsely and sparsely punctate. Length 5 mm. The only specimen before me is much broken and was taken at Fort Tejon about the end of May."

Type. The type specimen in the Leconte Collection, MCZ type No. 5070, is a male in fair condition. It is labeled "Cala." As far as known, this is the only specimen which has been collected. Weise, in the *Coleopterorum Catalogus*, pars 78, 1924, listed the range as the same as that of *S. schwarzi*, "Oregon, Lower California," but this requires confirmation.

The strongly curved, toothed hind tibia of the males makes this species very easy to identify. An examination of the type showed that the middle tibiae do have apical spurs. None could be observed, however, on the front or hind tibiae.

SCELOLYPERUS MEGALURUS, NEW SPECIES

Figures 88, 89, 105

Elongate; elytra parallel; prothorax narrower than elytra; head and elytra metallic green; pronotum yellow.

Vertex dark metallic green, strongly alutaceous, with a few very faint punctures near interocular sulcus; coronal suture depressed near interocular sulcus; ocular and interocular sulci deep, pubescent; supratentoria prominent. Frontal tubercles black, strongly delimited, separated from orbit by a broad depression, interantennal carina moderately prominent, not well separated from tubercles, pubescent; clypeus very narrow; labrum emarginate at apex; with a row of eight hairs across middle. Genae very short.

Antennae reach nearly to middle of elytra; filiform; brown, except that basal segments are yellow; third segment one and one-half times length of second; fourth longer than third but not longer than second and third together.

Pronotum yellow with a very indistinct, irregular, brownish area on each side; surface evenly, moderately convex, very finely punctate; all margins pubescent; sides slightly arcuate, nearly parallel.

Scutellum dark brown or black, alutaceous. Elytra slender; sides parallel, evenly convex (very slight indication of carinae in type but not in other specimens); surface alutaceous; punctures moderate in size, closely spaced; in some areas there is a very slight tendency to form longitudinal rows; apical half with a few erect hairs. Epipleura alutaceous, narrow, becoming indistinct at apical third.

Body beneath black or dark brown. Prosternum extends very narrowly between coxae; front coxal cavities open. Legs dark; anterior tibiae and tarsi paler. Posterior tibiae of male strongly curved; inner side with a broad, shallow, alutaceous sulcus running from base to apex. Middle tibiae of male with apical spur; no spur on front or hind tibiae. Basitarsus of all tarsi of male broad, oblong. Tarsal claws appendiculate.

Last ventral abdominal segment broadly flattened; truncate at apex; with a very short, broad, apical lobe deflected into cavity. A transverse, pubescent depression just before apex. Last external, dorsal sclerite (figure 88) greatly extended at apex into a long, narrow, deeply channeled process. The following sclerite (more or less internal) is also produced, with its apex lying in the channel of the preceding segment.

Aedeagus symmetrical, with small orifice at apical fourth, not covered by a sclerotized plate; apex broadly truncate, not narrower than rest of organ; a distinct joint at apical third. In lateral view regularly arcuate, curved upward at apex; base without distinct spurs. Apex below without distinct carinae but with a narrow median groove running from apex to joint at apical third.

Female with elytra normal as in the male; posterior tibiae straight; spurs on all tibiae.

Length 4.7 to 6 mm.

Holotype. ♂, Kaweah, Tulare Co., California, 1,000 ft. (CAS, W).

Paratypes. 3 ♂, 2 ♀ ♀, same data as holotype; 2 ♂, 3 ♀ ♀, Tulare Co., Cal. (CAS, USNM); 2 ♂ ♂, 1 ♀, Kaweah, Cal. (OSU); 1 ♂, Cal. (MCZ), 1 ♂, Cal., 74 (USNM); California (U. MICH.).

This species also is very close to *loripes* and may be so labeled in some collections. The greatly produced last dorsal abdominal segment of the male will readily distinguish this species.

One specimen in the USNM collection from Tulare County, southern California, is a male very similar to the types of *S. megalurus*. It differs in possessing a prominent spur on the apex of each front tibia; the aedeagus is slightly more curved; the specimen is slightly less pubescent, especially on the legs; the hind tibiae are slightly less deformed; and it is slightly smaller. In other characteristics it agrees very well with the type of *megalurus*—so well that no name is given to it. It is possible that spurs may break off, and it is also possible that presence or absence of tibial spurs is a variable character in some species. More material, preferably with some biological data, will be necessary before any definite conclusion can be reached.

SCELOLYPERUS LORIPES HORN

Figures 87, 102

Types. The male lectotype, No. 3800 in the Horn collection at the Philadelphia Academy of Science, is from California. A male paratype, No. 3800 "Cal," is also in the Horn collection.

The author has dissected the paratype. It is identical with the lectotype, except for color, which is more greenish. The lectotype has the aedeagus partially visible.

The paratype differs from the description of *S. ratulus* as follows: Elytra more distinctly green. Pronotum smooth between very fine punctures, not alutaceous. Surface of elytra very strongly alutaceous, rugulose, moderately finely punctate; punctures usually separated by one and one-half times their diameter. Hind tibia definitely curved. Apical lobe of abdomen much reduced, width about eight times length. Aedeagus very similar to *S. ratulus*, differing in lack of lateral, ventral, apical carinae, which are merely indicated at their bases. Apical spurs on all tibiae of male, very small, difficult to see.

Other specimens examined. Three males and three females, Sugar Pine, California, A. Fenyes (CAS).

SCELOLYPERUS RATULUS, NEW SPECIES

Figure 103

Elongate; elytral sides parallel; pronotum narrower than elytra. Head, elytra, and underside dark metallic blue; pronotum and basal

segments of antennae yellow; legs dark brown; femur with blue luster.

Head, except tubercles, strongly alutaceous. Ocular sulcus distinct; tubercles delimited behind by deep interocular sulcus, separated by a deep, narrow, median sulcus which extends as a broader depression above interocular sulcus. Interantennal carina prominent. Third antennal segment nearly half again as long as second; fourth almost but not quite so long as second and third together.

Pronotum narrower at apex than at base, widest at apical third, rather strongly arcuate in apical half. Surface evenly, moderately convex; alutaceous; finely, sparsely punctate.

Elytra half again as wide as pronotum at base; length of each is three times width. Sides parallel in basal two-thirds. Surface moderately, evenly convex; strongly alutaceous; moderately, closely punctate; punctures separated by about their diameters, irregular in shape. Surface with a few scattered hairs, especially in apical half. Epipleuron moderately broad in basal half, becoming narrower at middle, distinct to apex. Posternum narrowly separating coxae; front coxal cavities open. Tarsal claws appendiculate. Hind tibia only slightly curved. All tibiae with apical spurs in both male and female. Last ventral abdominal segment of male very broadly, transversely depressed; median apical lobe moderately depressed, short, width four times length. Aedeagus broadest at apex, truncate; orifice without sclerotized plate.

Length 5 mm.

Holotype. A male specimen in the Leconte collection at MCZ labeled "Cal." Allotype. Female, same data, in Leconte collection.

This species differs from *flavicollis* in the form of the aedeagus and also in possessing spurs on all tibiae. It is similar in appearance to *S. megalurus* but differs in the form of the hind tibiae which is less strongly curved and in not having the last dorsal abdominal sclerite strongly produced. Comparison with *loripes*, which it most closely resembles, is included in the section dealing with *loripes*.

SCELOLYPERUS FLAVICOLLIS (LECONTE)

Figure 95

Horn, 1893, described this species as follows: "Form oblong, parallel, above blue or green, metallic, thorax yellow, legs piceous. Antennae two-thirds the length of the body, piceous, the three basal joints bicolored. Head metallic green, impunctate. Thorax yellow, broader than long, slightly narrower in front, sides feebly arcuate, disc convex, smooth, impunctate. Elytra with feebly arcuate sides,

disc sparsely finely punctate, less distinctly at apex, surface metallic green or blue, distinctly alutaceous. Body beneath and legs piceous, with distinct greenish surface.

"Male. Last ventral truncate at middle, a light sinuation each side, disc flattened."

Length 6.5 to 7 mm.

Type. The MCZ type No. 4350 in the Leconte collection is a male labeled "Cala." "*flavicollis* Lec., Tejon."

Other specimens examined. There are also two females and one other male in the Leconte collection labeled "Cala." and two males labeled "So. Cal." Also ARIZONA: 1 ♀, S. Diego (CARNEGIE-Ulke); 2 ♂♂, 7 ♀♀, Paraiso Springs, May (CAS); 1 ♂, 3 ♀♀, Tehachapi, May (CAS); 1 ♂, Bradley, April (CAS); 2 ♂♂, 1 ♀, Lebec, May, alt. 4000 ft. (CAS); 1 ♂, Stone Cn., Monterey Co., April (CAS).

SCELOLYPERUS TORQUATUS (LECONTE)

Figure 96

Form elongate; sides of elytra parallel. Pronotum distinctly narrower than elytra. Head and elytra dark with distinct green or blue luster; prothorax yellow; legs and antennae dark.

Head dark; vertex and orbits with green luster; front and labrum brown. Vertex alutaceous, impunctate. Ocular sulcus distinct, wide, shallow, with a few hairs. Supratentoria small, indistinct. Coronal suture not impressed. Interocular sulcus deep, narrow, pubescent. Tubercles distinct, moderately swollen, rectangular, with surface smooth, shiny. Tubercles separated from orbit on each side by a broad, shallow, strigose depression; separated from each other by a deep triangular extension of the interocular sulcus; separated from interantennal carina by a distinct sulcus. Interantennal carina prominent; moderately, strongly swollen; raised above the level of the tubercles; not extending between tubercles.

Antennae of male filiform, reaching middle of elytra; brown, except that segments 2, 3, and 4 and underside of segment 1 are yellow. Segment 3 slightly longer than 2 but not one and one-half times as long; segment 4 almost half again as long as 3, not so long as 2 and 3 together.

Pronotal width equals 1.24 times length; pronotum a little wider at base than at apex, widest at apical third; sides moderately curved; basal margin broadly emarginate at middle. Pronotum moderately convex, without impressions; surface alutaceous, finely punctate;

punctures separated by three to six times their diameters. Scutellum brown, shining, very finely alutaceous. Elytra nearly half again as wide as pronotum at base. Length of each elytron 3.8 times the width. Humeri moderately prominent, with a broad, shallow depression between humerus and disc. Elytra moderately, evenly convex. Surface distinctly alutaceous; punctures moderately coarse, separated by a distance equal to their diameters; surface with a very few scattered hairs near apex.

Epipleura moderately broad at base, gradually becoming narrow, distinct to apical angles. Prosternum narrowly separating coxae; front coxal cavities open. Both male and female with all tibiae straight and armed with apical spurs.

Male with last ventral abdominal segment broadly flattened in middle, broadly truncate, without apical lobe. First tarsal segment of front and middle tarsi slightly swollen. Aedeagus without basal spurs; orifice a little beyond middle, symmetrical, without sclerotized plate; apex broadly rounded, asymmetrical with a right-angled tip on the left side. Aedeagus straight in lateral view.

Length 3.3 to 4.5 mm.

Type. The types were collected in San Mateo and Mariposa, California.

Other specimens examined. CALIFORNIA: 1 ♂, Clear Creek, Cuyama Cn., III-22-40, W. F. Barr (W); 1 ♀, Pine Mountains, San Luis Obispo Co., Apr. 15, 1951, Edwards (W); 1 ♀, Hot Springs, Tulare Co., VI-18-1927, Leach (CARNEGIE); 1 ♂, Pasadena, VI (CARNEGIE); 11 ♂♂, 8 ♀♀, San Diego Co., April (CAS); 2 ♂♂, 4 ♀♀, Sequoia Natl. Park, Alt. 2000-5000, May and June (CAS); 6 ♂♂, 2 ♀♀, Paraiso Springs, May (CAS); 2 ♂♂, Ash Mt., Tulare Co. (CAS); 1 ♂, Gen. Grant Natl. Park, June, *Pinus ponderosa* (CAS); 3 ♂♂, 2 ♀♀, San Benito Co., May (CAS); 1 ♂, 8 ♀♀, Cypress Ridge, Alameda Co., May (CAS); 1 ♂, 7 ♀♀, Anderson Sprs., Lake Co., March (CAS); 2 ♂♂, 1 ♀, Mt. Lowe, May (CAS); 1 ♂, 3 ♀♀, Cedar Ridge, Alameda Co., March (CAS).

This little species seems to be fairly common in southern California. The comparatively coarse elytral punctation and broader aedeagus easily distinguish this species.

A second form (variety No. 560) is very close to typical *S. torquatus* and may be merely a variant of that species. It is more often blue, a little more coarsely punctate; and the aedeagus is distinctly narrowed from middle to apex. Otherwise, it is identical with *torquatus*.

Specimens of the variety which the author has examined. CALIFORNIA: 1 ♂, Mt. S. Antonio, Jl. 3, 1911, P. H. Timberlake (USNM); 1 ♂, Avalon, St. Catalina, A. W. H. (USNM); 4 ♂♂, 11 ♀♀, Lebec, V-13-1928, Alt. 4,000 ft., Martin (CAS, W); 1 ♂, 1 ♀, Los Angeles, Klages (CARNEGIE); 1 ♂, San Diego (CARNEGIE); 1 ♂, 2 ♀♀, Bear Valley, S. Bba. Co., June (CAS); 1 ♂, 13 ♀♀, Orange Co., April (CAS); 2 ♂♂, 2 ♀♀, Los Angeles Co., (CAS); 3 ♂♂, 1 ♀, San Diego Co. (CAS); 4 ♂♂, 1 ♀, Poway (CAS). BAJA CALIFORNIA: 1 ♂, Rosario, 8-III-49, Alger (USNM).

SCEOLYPERUS TRANSITUS (HORN)

Figure 93

Form elongate; sides of elytra parallel; pronotum distinctly narrower than elytra. Elytra dark metallic blue or blue-green; prothorax, tibiae, tarsi, apical part of femora, and basal segments of antennae yellow; head, abdomen, mesosternum and metasternum, femora, and apical antennal segments black or dark brown.

Head black; lower part of front, labrum, and mandibles yellow or pale brown. Vertex moderately alutaceous, impunctate or nearly so. Ocular sulcus distinct, deep, narrow, with a few hairs. Supratentoria small, but distinct. Coronal suture indistinct. Interocular sulcus deep, narrow. Tubercles prominent, flat, more or less rectangular, with surface faintly alutaceous, separated from orbit by broad, shallow depression containing several narrow, longitudinal grooves. Tubercles not confluent. Interantennal carina prominent, moderately swollen, extending between tubercles, separated from tubercles by distinct sulci. Antennae normal, filiform, reaching middle of elytra; segment 3 longer than 2 but not one and one-half times as long; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotal width greater than length but not one and one-half times length; width at apex slightly less than at base, widest at apical third; sides straight, divergent in basal half, moderately arcuate in apical half. Pronotum only slightly, evenly convex; disc flattened; pronotum with faint indication of median depression. Surface of pronotum glabrous, smooth, shiny, with very fine indistinct punctures.

Elytra slightly wider than pronotum at base; humeri moderate; indistinct sulcus between humerus and disc. Length of each elytron equal to four times width. Surface of elytra moderately, evenly convex; moderately alutaceous; punctures fine, separated from each

other by a distance equal to two or three times their diameters; elytra with a very few scattered hairs near apex.

Epipleuron moderately broad in basal fourth; becoming narrow and indistinct at apical third. Prosternum narrowly separating front coxae; front coxal cavities open. Male with last ventral abdominal segment broadly truncate, with extremely short, deflexed apical lobe; segment broadly flattened at middle. Apical spurs on all tibiae of male. Basitarsi of all legs in male with pulvillus below; first segments of front and middle tarsi broader than normal in male. Basitarsus of hind leg longer than segments 2 and 3 together but not so long as all following together. Tarsal claws appendiculate.

Aedeagus without basal spurs. Form spatulate; apical widened portion bent to the right. Apex unevenly rounded, somewhat asymmetrical. Orifice at apical third symmetrical, not covered with sclerotized plate.

Length 4 mm.; width 1.3 mm.

Type. The type is in the Horn collection, Academy of Natural Sciences of Philadelphia. The description above was drawn from a ♂ paratype (No. 3805.8, from California) in the same collection.

Other specimens examined. CALIFORNIA: 3 ♂♂, 1 ♀, Carmel, Monterey Co., April (CAS); 7 ♂♂, Jamesburg, Monterey Co., April (CAS); 5 ♂♂, 1 ♀, Paraiso Springs, May (CAS); 2 ♂♂, 1 ♀, Fairfax, April, *Ceanothus* (CAS); 1 ♂, 5 ♀♀, Santa Monica, April (CAS); 1 ♂, 2 ♀♀, Martin Co. (CAS); 2 ♂♂, 1 ♀, Stone Co., April (CAS); 4 ♂♂, Pine Valley, San Diego Co., April (CAS); 2 ♂♂, 2 ♀♀, Oroville, March-April, ex. *Ceanothus cuneatus* (CAS); 1 ♂, 4 ♀♀, Mt. Diablo, Contra Costa Co., April (CAS); 2 ♂♂, 4 ♀♀, Kaweah (CAS).

One of the Jamesburg specimens is labeled "Com. on W. Gooseberry."

S. phenacus, *laticeps*, *phoxus*, and *transitus* are very similar in external appearance. *S. transitus*, however, differs from the others in the form of the aedeagus, which in this species is curved upward in lateral view. In the others, the aedeagus is strongly sinuate in lateral view.

SCELOLYPERUS LATICEPS (HORN)

Figure 99

Form elongate; sides of elytra parallel; pronotum distinctly narrower than elytra. Prothorax yellow; head, mesosternum and metasternum, and abdomen black; elytra black with faint green luster.

Head black; labrum and front dark brown. Vertex moderately alutaceous, shiny, impunctate. Ocular sulcus distinct, shallow. Supra-tentoria indistinct. Coronal suture not impressed. Interocular sulcus deep, narrow. Tubercles distinct, flat, rectangular; surface shiny, faintly alutaceous. Tubercles confluent with orbit on each side or separated by a broad, faint depression; each separated from inter-antennal carina by a very fine sulcus; separated from each other by a deep sulcus (forward extension of interocular sulcus). Interantennal carina broad, moderately swollen, extending slightly between the tubercles.

Antennae filiform, reaching to middle of elytra, brown; basal three or four segments pale; first segment dark above. Segment 3 a little longer than 2 but not one and one-half times length of 2; segment 4 about as long as 3 or very little longer.

Pronotal width equal to one and one-half times length, slightly narrower at apex than at base, widest at apical third. Sides somewhat sinuate, strongly curved in apical half. Surface moderately, evenly convex, without impressions; extremely finely punctate, not alutaceous.

Scutellum black, smooth, alutaceous at base. Length of each elytron four times width; humeri prominent, separated from disc by a broad shallow depression. Surface moderately, evenly convex; strongly alutaceous. Punctuation very fine; punctures separated by a distance three or four times their diameters. A few scattered hairs near apex.

Epipleuron moderately broad in basal half, becoming gradually narrower, more or less distinct to apex. Prosternum narrowly separating coxae. Legs dark except for front tibia, apical half of front femora, and apex of middle femora. Apical spurs on all tibiae in both male and female. Male with last ventral abdominal segment broadly flattened in middle; apex broadly truncate, without apical lobe. Basitarsus of front and middle tarsi swollen. First segment of hind tarsus about as long as the following two segments together.

Aedeagus without basal spurs, strongly sinuate in lateral view. Orifice symmetrical, without sclerotized plate. Apex broad, asymmetrical, with rectangular point at left side.

Length 3.5 mm.

Type. The male lectotype, No. 3806 in the Horn collection (PHILA.), is from California.

Other specimens examined. IDAHO: Horseshoe Bend, VI-18-54, Knowlton (OSU, W). CALIFORNIA: 1 ♂, Cal., C. V. Riley (USNM); 1 ♂, 1 ♀, Mendocino Co., VI-26-1919, Leach (CAR-

NEGIE); 1, San Francisco (CAS); 1 ♂, Dunsmuir, Wickham (USNM); 1 ♂, 1 ♀, Los Altos, May (CAS); 1 ♂, Carrville, Trinity Co., alt. 2,400-2,500 ft., May (CAS); 6 ♂♂, 6 ♀♀, Oakland, April (CAS); 9 ♂♂, 1 ♀, Yorkville, Mendocino Co., April (CAS); 5 ♂♂, 4 ♀♀, Lake Co., May (CAS); 1 ♂, Alameda (CAS); 1 ♂, Mt. Diablo, April (CAS).

This small species is very similar in general appearance to *S. transitus* and *phoxus*. The aedeagus in lateral view is sinuate, differing in this respect from *transitus*. The apex of the aedeagus is blunt, with the tip turned far to the side; while that of *phoxus* is much more nearly symmetrical and pointed.

SCELOLYPERUS PHOXUS, NEW SPECIES

Figures 92, 98

Head and elytra black with faint greenish luster; pronotum yellow. Antennae brown; basal four or five segments yellow. Legs dark; front and middle tibiae and tarsi pale. Tubercles and front brown. Vertex smooth, shiny, with a few very fine punctures. Ocular sulcus narrow, deep. Supratentoria small, indistinct. Coronal suture indistinct, but surface of vertex near interocular sulcus strigose. Tubercles rectangular; surface smooth, shiny. Tubercles not distinctly separated from orbit on each side; separated from interantennal carina by rather deep, narrow sulci. Interantennal carina extending partially between tubercles. Antennae reaching basal third of elytra. Segment 3 is one and one-half times as long as 2, segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotal width one and one-half times length. Pronotum slightly wider at apex than at base, widest at apical third. Sides evenly, moderately arcuate. Surface smooth, with extremely fine punctation. Elytra half again as wide as pronotum at base; sides parallel; length of each a little more than three times width. Humeri prominent with distinct sulcus between humerus and disc. Punctation of elytra fine; punctures separated by a distance equal to three or four times their diameters. Surface alutaceous, very finely, transversely rugulose, with a few scattered, erect hairs on apical half.

Elytral epipleura moderate in width at base, gradually becoming narrower; becoming indistinct at apical third. Last ventral abdominal segment of male with an extremely short, wide, strongly deflected apical lobe; its width is about 10 times its length. All tibiae of male with apical spurs. First segment of front and middle tarsi in male somewhat enlarged; that of hind tarsus cylindrical, longer than the

following two segments together but not so long as all the following segments together. All basitarsi with pulvillus below.

Aedeagus with apex asymmetrical, pointed; tip not far from median axis, slightly raised. Orifice at apical third. Aedeagus, in dorsal view, slightly narrowed near orifice producing a spatulate form; strongly sinuate in lateral view.

Length 3.8 mm., width across humeri 1.3 mm.

Holotype. Male, Lower Santa Ana Canyon, California, V-8-33, Green River Camp, VanDuzee (CAS).

Paratypes. CALIFORNIA: 2 ♂♂, 2 ♀♀, same data as holotype (CAS, W); 1 ♂, S. Anita Canyon, 4-11-16 Martin (CAS); 1 ♂, Pomona, Wickham, 1933, No. 525 (USNM); 1 ♂, Los Angeles Co., Coquillett coll'n (USNM).

This small species was identified by Wickham as *laticeps*. It is very close to *laticeps* but differs in having more distinctly punctate elytra and in the more pointed, less asymmetrical aedeagus.

SCELOLYPERUS CARINATUS, NEW SPECIES

Figures 91, 159

Head, mesosternum and metasternum, and abdomen black; elytra dark metallic blue or blue-green; prothorax, antennae, and legs yellow; femora darkened at least at base; antennae normal, filiform. Vertex shiny, very faintly alutaceous, with a few, fine punctures. Ocular sulcus shallow, pubescent. Supratentoria very small, distinct. Tubercles very prominent, flattened, somewhat rectangular; surface smooth, shiny, confluent with orbit on each side. Antennae reaching basal third of elytra in female, beyond middle in male. Antennal segment 3 longer than 2 but not one and one-half times as long; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotal width greater than length but not quite one and one-half times length. Pronotum widest at apical third, wider at base than at apex; sides moderately arcuate in apical half; disc flattened, with small, very faint impression each side of middle; smooth, not alutaceous; extremely finely punctured. Elytra slightly wider than pronotum at base. Humeri moderate with distinct sulcus between humerus and disc. Length of each elytron is three times width. Each elytron of both male and female with a very prominent, acute carina extending back from humerus. Marginal bead hidden by carina in dorsal view. Surface between carinae moderately convex; finely punctate; punctures separated by a distance equal to two or three times their diameters. Surface between punctures moderately alutaceous.

Epipleura moderately broad in basal third, becoming narrower at middle and very narrow at apical fifth. Basal segment of posterior tarsus of male equal in length to 2 and 3 together.

Aedeagus symmetrical; apex gradually narrowed, sharply pointed. Length 3.3 to 4.7 mm.

Holotype. Female, Humboldt Co., California, 13.6, Bair's Rch., Redwd. Crk., H. S. Barber, No. 512, USNM type No. 67420.

Paratypes. CALIFORNIA: 1 ♀, same data as holotype (USNM); 3 ♂♂, Ahwahnae, May, Fenyas (CAS); 3 ♂♂, 5 ♀♀, Humboldt Co., V-22-11, F. W. Nunenmacher (CHICAGO, U. MICH.). OREGON: 1 ♀, Oak Ridge, VI-1-24, Hopping (CAS).

These little beetles look very much like *S. phenacus*. However, the carinate elytra and pale prothorax will separate them from all other known species.

SCELOLYPERUS PHENACUS, NEW SPECIES

Figure 100

Head, elytra, femora, and ventral surfaces black or dark brown; elytra with very faint greenish luster; prothorax yellow; antennae, tibiae, and tarsi light brown to yellow.

Vertex black with faint aeneous luster; surface faintly alutaceous, very finely punctate or impunctate. Interocular sulcus narrow; ocular sulcus well defined. Tubercles black, separated by interantennal carina in part, not distinctly delimited from orbit. Antennae reaching middle of elytra; third segment only slightly longer than second; fourth only slightly longer than third.

Pronotum short, wide; width is one and one-half times length; widest at apical third; margins strongly curved in apical half, nearly straight in basal half but strongly converging to base. Front angles small, tuberculate; posterior angles prominent, nearly rectangular. Surface smooth, shining, extremely finely punctate. Elytra evenly convex; surface alutaceous, slightly rugose and punctures fine, shallow; a few erect hairs scattered on apical half of elytra. Epipleura narrow, becoming obsolete at apical fifth.

Spurs on all tibiae of male. All basitarsi normal, not swollen. First segment of hind tarsus longer than the following two segments but not the following three segments together. Last ventral abdominal segment of male about as long as the three preceding together; median apical portion flattened, truncate without distinct apical lobe. Aedeagus very slender, symmetrical; orifice at apical third; apex in dorsal view appearing to be truncate, the blunt tip sharply turned up; in lateral view, the organ is strongly sinuate.

Length 3.4 to 3.8 mm.

Holotype. A male, Chester, California, VII-1-51, D. J. and J. N. Knull, No. 68 (OSU).

Paratypes. 1 ♀, same data as holotype (OSU). 3 ♂♂, Tallac, California, July, Fenyess coll'n (CAS, W).

This species is nearly identical, externally, with *S. laticeps* and *S. transitus*. In *transitus* the prothorax is not so strongly constricted at the base; the sides of the pronotum are much less arcuate, and the aedeagus is distinctly spatulate. In *laticeps* the aedeagus is much broader and distinctly asymmetrical, and the elytra are a little more blue.

SCELOLYPERUS SCHWARZI HORN

Figure 97

Metallic blue or green, except basal antennal segments and front and middle tibiae which are more or less yellow. Head blue or green; vertex smooth or alutaceous, very finely punctate; a few moderate punctures near eye. Coronal suture depressed near interocular sulcus; ocular and interantennal sulci deep, pubescent; supratentoria prominent. Frontal tubercles usually separated from orbit by narrow sulcus. Front below eyes closely punctate, pubescent. Clypeus narrow, yellow. Labrum brown, broadly emarginate at apex, with a row of six hairs across the middle. Antennae nearly reaching middle of elytra, brown, basal four segments yellow with upper surface darker. Third segment one and one-half times length of second; fourth longer than third but not quite so long as second and third together.

Pronotum metallic blue or green; width is one and one-third times length; pronotum widest at apical third, arcuate in apical half. Surface with fine and moderate punctures mixed, closer and coarser near sides and base. Elytra evenly convex; surface alutaceous, finely, closely punctate; somewhat rugose at sides. A rather distinct sulcus between humerus and disc. A few erect hairs scattered near apex. Epipleura alutaceous, narrow, becoming indistinct at apical third.

Body beneath dark brown with very distinct blue or green luster. Posterior tibiae of male strongly curved, inner side glabrous, shining, not sulcate. Posterior tibia of female nearly straight. Apical spurs only on front and middle tibiae of male, on all tibiae of female. Basitarsus of all tarsi of male very broad, oblong; dorsal surface of posterior basitarsus flattened, glabrous, shining; posterior basitarsus slightly longer than the following two segments together. Apex of last ventral abdominal segment with a short, broad lobe; lobe with a transverse band of short dense pubescence. Aedeagus symmetrical,

constricted before basal section; with small, round orifice at apical third. Apex rounded, with small, deep emargination; without a "joint" at apical third. In lateral view the aedeagus is regularly arcuate, curved upward at apex. Ventral surface with carina in basal half, becoming flattened just before basal section of organ.

Length 4.9 to 5.3 mm.

Range. This species is known from California north to Lumby, Trinity Valley, and Kelowna, British Columbia; also from Idaho and Chinook Pass, Wyoming. Weise, in the *Coleopterorum Catalogus*, lists it from Baja California.

Some specimens of this species which M. H. Hatch sent for study were labeled *Luperodes varipes*. These plus the description indicate that the species called *varipes* by Beller and Hatch, 1932, is actually *S. schwarzi*.

Males of this species are easily identified. They are the only ones with dark pronotum, emarginate aedeagus, and strongly curved hind tibiae. Females are nearly identical with *S. varipes* and may be separated from that species with difficulty. See the discussion of *varipes* for a comparison of the females of the two species.

SCELOLYPERUS CURVIPES, NEW SPECIES

Figures 84, 85

Male. Body, legs, and antennae black or dark brown; elytra dark metallic blue or purple. Head normal, very dark brown; vertex black with very faint blue, purple, or bluish green luster; alutaceous; extremely finely, sparsely punctate. Ocular sulcus deep. Supratentoria small but distinct. Coronal suture indistinct, not impressed. Interocular sulcus very distinct, deep. Frontal tubercles quadrangular, flat, finely alutaceous, impunctate. Tubercles confluent with orbit on each side but broadly depressed at sides; interantennal carina extending partly between tubercles. Antennae reach a little beyond middle of elytra; brown; first four segments yellow on basal, ventral half. Antennal segment 3 longer than 2 but not one and one-half times as long; segment 4 distinctly longer than 3 but not so long as 2 and 3 together.

Pronotum a little wider than long, widest at middle, distinctly wider at base than at apex; sides in basal half nearly straight and parallel, moderately arcuate in anterior half. Disc of pronotum flattened, smooth, shining, extremely finely punctate. Pronotum black; anterior and posterior quarters may be brown. Elytra across humeri a little more than one and one-half times width of pronotum at base;

moderately, evenly convex. Humeri prominent, separated from disc by a broad, shallow, basal sulcus. Surface alutaceous, somewhat rugose; punctures rather coarse, shallow, separated from each other by a distance equal to one to two times their diameters.

Epipleura moderately broad at base, becoming rather abruptly narrower at middle; narrow but distinct nearly to the sutural angles. Hind tibiae strongly curved, with a very broad, smooth channel on inner side running the whole length. Ventral margin of this channel broadly explanate in apical half. Front and middle tibiae with apical spurs; none on hind tibiae. First segment of all tarsi swollen, as wide as tibia at apex, with pulvillus covering whole ventral surface.

Last ventral abdominal segment of male with a broad, shallow, transverse depression at middle; truncate at apex with a very broad, short, strongly deflexed apical lobe. In lateral view, aedeagus is moderately curved upward; with a membranous, longitudinal sulcus on each side. In dorsal view, aedeagus symmetrical; orifice at apical fourth, small. Sides nearly parallel; apex distinctly broader than rest of organ, broadly truncate.

Female not known.

Length 5.7 to 6 mm.

Holotype and paratypes. 8 ♂♂, Boulder Creek, Fresno Co., Calif., May 24, 1911, Hopping coll'n (CAS, W).

S. curvipes is quite similar in general appearance to *S. smaragdinus*, *graptoderoides*, and *schwarzi*. It differs from the first two in the strongly curved hind tibia of the male. *S. schwarzi* also has curved hind tibiae in the male but lacks the broadly explanate margins of the wide sulcus on the inner side.

SCELOLYPERUS SMARAGDINUS LECONTE

Figures 94, 153

Body, elytra, and femora dark metallic blue or purple. Tibiae, tarsi, and antennae dark brown or black; basal segments of antennae lighter brown. Head dark metallic blue or purple; labrum and mandibles brown. Vertex shining, impunctate, feebly alutaceous. Ocular sulcus shallow; indicated by a row of moderately coarse, irregular punctures. Supratentoria small, not always distinct. Tubercles flat or only slightly concave, nearly rectangular or broadly curved around antennal insertion; surface smooth, shiny. Tubercles confluent with orbit on each side. Interantennal carina not extending between tubercles. Antennae reach apical third of elytra. Segment 3 twice as long as 2; segment 4 about as long as 2 and 3 together.

Width of pronotum one and one-third times length along median line; pronotum wider at base than at apex, widest at apical third. Sides in basal half straight, very slightly divergent from base, moderately arcuate in apical half. Apical margin slightly concave; basal margin sinuate, concave at middle. Pronotum very finely punctate; surface between punctures smooth and shiny. Elytra nearly half again as wide as pronotum at base. Length of each elytron three times width. Humeri prominent with distinct sulcus between humerus and disc. Surface of elytra moderately, evenly convex. Moderately, closely punctate; punctures separately by one to one and one-half times their diameters in median subsutural area. Surface between punctures shiny, slightly to strongly alutaceous, with a very few scattered hairs near apex.

Epipleura moderately broad in basal half, becoming narrower at middle; narrow but distinct to apical angles. Last ventral segment of male without apical lobe. Posterior tibiae slightly curved. Apical spurs on all tibiae. Basitarsus moderately swollen on middle tarsus, more nearly normal on front and hind tarsi. Basitarsus of hind leg as long as the following two segments together. Aedeagus with apex asymmetrical, with small, acute point; orifice located at apical third of organ.

Length 6 to 6.4 mm.

Type. The MCZ type No. 4340 is a male bearing the gold disc which indicates the specimen came from California.

Other specimens examined. CALIFORNIA: Livermore, u-11-30 (W); Pasadena (NYSM); 2, Pasadena, vii-2, Fenyès (CARNEGIE); 1, Nevada Co., v-26-1927 (CARNEGIE).

SCEOLYPERUS GRAPTODEROIDES (CROTCH)

Figure 108

Horn, 1893, described this species as follows:

"Head and thorax greenish blue, elytra cobalt-blue, body beneath and legs piceous, with distinct bluish tinge. Antennae two-thirds the length of the body, piceous; the three basal joints paler beneath. Head smooth. Thorax slightly wider than long, a little narrower at apex, sides feebly arcuate in front, then parallel to base, disc moderately convex, sparsely finely punctate, surface alutaceous. Body beneath and legs piceous, with bluish lustre.

"Male.—The ventral characters are as in *flavicollis*; the first joint of front tarsus slightly dilated and thickened."

Length 6.6 to 7 mm.

Type. The MCZ type No. 5071 in the Leconte collection is a male bearing a gold disc which indicates it came from California. Crotch states it came from Santa Barbara, Santa Bueneventura.

Dissection of the type shows the aedeagus is similar to that of *S. smaragdinus*, except in the form of the apex. This is only slightly asymmetrical and more evenly rounded without any indication of a point. *S. graptoderoides* is also similar to *smaragdinus* in form and color but differs in the lack of apical spurs on all tibiae in the male.

SCELOLYPERUS VARIPES (LECONTE)

Figure 107

Elytra and body, above and below, metallic blue or green. Antennae filiform; basal three segments pale; apical segments dark brown. Front leg yellow; femur brown in basal half. Middle and hind legs black; middle femur pale at apex. Head entirely dark metallic blue or green; vertex strongly alutaceous, very finely punctate. Ocular sulcus distinct, narrow, deep. Supratentoria small but distinct. Tubercles very distinct, rectangular; surface smooth or faintly alutaceous. Tubercles confluent with orbit on each side. Interantennal carina extends between the tubercles. Antennae reach middle of elytra; segment 3 slightly longer than 2 but not one and one-half times as long; segment 4 as long as 2 and 3 together.

Width of pronotum is 1.2 times length. Pronotum slightly wider at base than at apex, widest at apical third; sides usually rather evenly curved. Surface finely punctate, slightly alutaceous. Elytra half again as wide as prothorax at base; each elytron nearly four times as long as wide. Humeri prominent with a distinct sulcus between humerus and disc. Surface of elytra moderately, evenly convex. Punctuation moderate; deep punctures separated by a distance equal to two or three times their diameters. Surface between punctures strongly alutaceous, with a few scattered hairs near apex.

Epipleuron moderately broad in basal half, becoming narrower at middle but distinct to apical angles. Apical spurs on all tibiae in both male and female. Last ventral abdominal segment of male without apical lobe. Hind tibiae straight. Front and middle basitarsi slightly swollen. First segment of hind tarsus shorter than second and third together. Aedeagus with orifice at apical third; apex asymmetrical, rounded, strongly produced.

Length 3.8 to 4.8 mm.

Types. The MCZ type No. 4341 came from San Francisco, California. It is a male. The type of *Luperus concavus* Beller & Hatch, a

female, is in the University of Washington collection and bears the data: "Mt. Ranier, Wash., Greenwater River, May 31, 1931, William W. Baker."

Specimens examined by the writer have come from southern California, Oregon, Washington, Idaho, Wyoming, Colorado, and Nevada.

S. varipes is apparently a common species on the Pacific Coast. It is quite variable, but no character or group of characters have been found which can be used to break this species into either subspecific or consistent varietal forms. The color ranges from blue to green with an occasional specimen exhibiting a distinct bronze luster. The surface of the pronotum, and to a lesser extent, of the elytra varies from smooth and shiny to strongly alutaceous and dull. Pronotal punctation is also variable in the size of the punctures and the distance between them.

SCEOLYPERUS MORRISONI (JACOBY)

Figure 109

S. morrisoni (Jacoby) is very close to *S. varipes* (Leconte). In the comparatively few specimens seen, the following characters differ from those of *varipes*. Antennal segments 2 and 3 equal in length; segment 4 almost, but not quite so long as 2 and 3 together. Tibiae and tarsi of front and middle legs yellow, those of hind legs somewhat darker, especially on outer or upper surface. Pronotum very slightly wider than long; width equal to 1.1 times length. The aedeagus is more rounded, and less strongly produced at apex.

Of these characters, only the form of the aedeagus appears to be reliable in identifying specimens. Possibly *morrisoni* should be considered to be a subspecies of *varipes*, but more specimens from Arizona are needed to settle the problem.

Length 4.4 to 5 mm.

Type. MCZ type No. 18146 in the Bowditch collection is a female labeled "N. Sonora, Mexico, Morrison, 1st Jacoby collection." This locality is, in fact, in Arizona. Undoubtedly other Jacoby types exist in the British Museum (Natural History).

Range. Known also from the Chiricahua Mts., Arizona, 9-6 (USNM).

SCEOLYPERUS CYANELLUS (LECONTE)

Figure 106

Body and legs dark brown or black; elytra dark metallic green or blue; pronotum black without metallic blue or green luster. Antennae

brown; basal segments yellow; front tibiae and tarsi brown or yellow.

Vertex strongly alutaceous, impunctate. Ocular sulcus distinct, deep, narrow. Coronal suture broadly, shallowly depressed. Tubercles with surface smooth, shiny and separated from orbit on each side by a broad depression. Antennae reaching basal fourth of elytra. Antennal segment 3 equal to 2 in length; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum narrower at apex than at base, widest at apical third; sides nearly straight and parallel in basal half; moderately arcuate in apical half. Pronotum wider than long but width is not quite one and one-half times length. Surface of pronotum sometimes with indistinct depression on each side on basal third or at middle near base. Surface impunctate, smooth and shiny, not alutaceous.

Elytra half again as wide as pronotum at base; sides parallel; humeri prominent. Surface of elytra moderately convex, may have very faint indications of longitudinal carinae extending back from humeri; punctation confused, finely punctate; punctures separated by a distance two or three times their diameters, strongly alutaceous between punctures. Epipleuron moderately broad in basal half, becoming narrower at middle; narrow but distinct to apical angle.

Last ventral abdominal segment of male without apical lobe. Apical spurs on all tibiae in both male and female. Basitarsus normal on all legs in male; that of hind leg about as long as segments 2 and 3 together.

Aedeagus with apex rounded, asymmetrical. Apical half almost twice as broad as basal half; sides parallel.

Length 4.4 to 4.8 mm.

Type. The male type, MCZ No. 4342, in the Leconte collection bears a yellow disc indicating "Western States." The aedeagus has been dissected from the type.

Other specimens examined. OHIO: 1 ♂, Delaware Co., V-21, D. J. & J. N. Knull (OSU). NORTH CAROLINA: 2 ♂♂, 30 ♀♀, Blue Ridge Pkwy., Bee Tree Gap, 5500 ft., June 21, 1952, D. M. Weisman. PENNSYLVANIA: 1 ♂, 6 ♀♀, Allegheny (CARNEGIE, W).

This species is quite similar to *meracus* in general appearance. The males may be identified easily by the unusual form of the aedeagus. Females are not so easy to identify; however, they differ slightly from the other species in the black pronotum which has no green or blue luster (at least in the specimens examined), in the black middle and hind tibiae, and darker apical antennal segments.

The Ohio specimen mentioned above is typical, except for a very distinct, round impression on each side of the pronotum just behind the middle.

SCEOLYPERUS BIMARGINATUS (BLAKE)

Figure 114

Body and elytra black or dark brown; elytra dark metallic green or blue; antennae brown, except that basal segments are yellow; legs dark, except that front and middle tibiae are paler. Vertex strongly alutaceous, with a few fine punctures. Ocular sulcus distinct, deep, with a few fine hairs. Supratentoria small, indistinct. Coronal suture broadly, shallowly depressed. Tubercles with surface smooth, shiny, separated from orbit on each side by a broad depression. Inter-antennal carina not extending between tubercles. Antennae reach nearly to middle of elytra; segment 3 a little longer than 2 but not one and one-half times 2; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum wider than long, but width is not quite one and one-half times length. Pronotum narrower at apex than at base, widest at apical third; sides nearly straight, divergent, in basal half; moderately arcuate in apical half. Disc of pronotum somewhat flattened, without distinct depressions or with a small depression on each side on basal third. Surface of pronotum impunctate, smooth, not alutaceous. Elytra half again as wide as pronotum at base; humeri prominent; each elytron with length equal to three times width. Surface of elytra moderately convex. Male with a very broad, moderately convex carina extending back from the humerus. Elytra of female with a very prominent, acute carina extending from humerus to apical angle. Marginal bead of elytra hidden in dorsal view by carina in female. Elytral punctures very fine, separated by a distance equal to three or four times their diameters. Surface of elytra between punctures strongly alutaceous. Epipleuron moderately broad in basal half, becoming narrower at middle, narrow but distinct to apical angles.

Last ventral abdominal segment of male without apical lobe. Hind tibia of male straight; with thin, apical lamellate lobe; apical spurs on all tibiae. Basitarsus on middle leg swollen. Basitarsus of hind leg longer than second and third together but not so long as second, third, and last. Aedeagus with apex rounded, asymmetrical; sides parallel; sinuate in lateral view.

Length 4.3 to 4.8 mm.

Type. The male holotype from Mt. Mitchell, N.C., 6,000 ft., June 20, 1926, F. Sherman, is in the U.S. National Museum, catalog No. 40974.

Range. Known only from the Great Smokies region of North Carolina and Tennessee (Black Mts., Mt. Mitchell).

Females of this species are easily identified by the strongly carinate elytra. No other species with dark pronotum possesses this character. The carinae are much less distinct in the male, which is similar in general appearance to *S. meracus*. The form of the aedeagus in lateral view is distinctive.

SCELOLYPERUS MERACUS (SAY)

Figure 115

Body and elytra dark brown or black; upper surface with distinct dark green or blue metallic luster. Clypeus and labrum paler, yellow. Antennae, tibiae, and tarsi yellow; femora darker. Vertex strongly alutaceous, with a few coarse or moderate punctures. Ocular sulcus distinct, deep, with a few hairs. Coronal suture broadly depressed. Interocular sulcus deep, narrow. Tubercles with surface alutaceous; separated from orbit on each side by a broad shallow depression. Interantennal carina moderately swollen; not extending between tubercles. Antennae reaching basal fourth of elytra; entirely pale. Segment 3 a little longer than 2 but not one and one-half times 2; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum a little narrower at base, widest at apical third; sides moderately arcuate in apical half, wider than long but not quite one and one-half times length. Surface of pronotum without distinct depressions, rarely with a faint depression on each side on basal third; finely, sparsely punctate; surface between punctures smooth, not alutaceous. Elytra half again as wide as pronotum at base. Humeri prominent. Surface of elytron without carinae or with a very faint indication of a longitudinal carina extending back from humerus. Surface very finely punctate; punctuation confused; punctures separated by a distance equal to two or three times their diameters. Surface between punctures alutaceous; with a few scattered hairs, especially on apical half.

Epipleuron moderately broad in basal half, becoming narrower at middle; narrow but distinct to apical angle. Last ventral abdominal segment of male without apical lobe. Hind tibiae straight; apical spurs on all tibiae in male. Basitarsus normal on all legs; that of posterior leg longer than segments 2 and 3 together. Aedeagus with apex rounded, asymmetrical. In dorsal view sides are nearly straight,

very slightly tapering to apex. Asymmetrical tip broad, evenly rounded. In lateral view, basal half (extreme base excepted) of aedeagus straight; apical third slightly sinuate, deflected.

Length 4 to 5 mm.

Type. Lost. Say mentioned no locality other than United States.

Specimens examined. NEW YORK: Berlin, VII-9-54, Wilcox, on witch hazel (NYSM, W); Heart Lake, Essex Co., Aug. 1, 1940, H. Dietrich (CORNELL). OHIO: 1 ♂, 5 ♀♀, Jefferson, Ash-tabula Co., 6-08, Robt. Sim (OSU). NEW HAMPSHIRE: White Mts., Mt. Madison, 5,380, VIII-3-1943, M. E. Smith, on *Betula* (W). MAINE: Mt. Bigelow, 4,000 ft., 7-VIII-54, A. E. Brower, on birch (W). PENNSYLVANIA: 4 ♂♂, 3 ♀♀, Jeannette, VI-10 to VII-4, Klages (CARNEGIE). KANSAS: 1 ♂, 2 ♀♀, Ks. (MCZ).

Hosts. Witch hazel (*Hamamelis virginiana* L.) and birch (*Betula populifolia* Marsh.).

There may be some doubt as to which species Say had before him when he described *meracus*. Some specimens of the witch hazel species do have acute posterior pronotal angles as described by Say and, since they agree in color, the name is applied to this species. Some specimens of *S. bimarginatus* (Blake) and *cyanellus* (Leconte) are close, but in these species the legs are too dark to fit Say's description. In *S. liriophilus*, new species and *chautauquus*, new species the legs are often entirely yellow; but in a few specimens the femora are dark. The posterior angles of the pronotum in these last two species are usually obtuse, rarely rectangular.

SCELOLYPERUS LIRIOPHILUS, NEW SPECIES

Figures 83, 116

Body and elytra entirely dark brown or black, upper surface with distinct green or blue metallic luster. Antennae and legs usually entirely yellow; femora may be darkened. Head, except tubercles, strongly alutaceous; ocular sulcus is pubescent near eyes. Antennae reach basal fourth of elytra. Antennal segment 3 a little longer than 2 but not one and one-half times 2; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum narrower at apex than at base, widest at apical third; sides moderately, evenly arcuate; width a little greater than length. Surface without distinct depressions in most specimens, but a few have a small depression on each side behind the middle. Surface smooth; not alutaceous; finely, sparsely punctate. Each elytron with

length equal to three times width. Humeri prominent; a wide shallow sulcus between humeri and disc of elytra. Surface of elytra moderately, evenly convex; punctures fine, separated by at least twice their diameters. Surface alutaceous.

Male. Last ventral abdominal segment truncate at apex without apical lobe. Legs entirely yellow or yellow with darker femora. Hind tibiae straight. Apical spurs on all tibiae. Basitarsus of hind leg longer than the second and third segments together. Aedeagus rounded at apex which is asymmetrical. Sides of aedeagus nearly straight in both lateral and dorsal views.

Length 3.3 to 4.5 mm.

Holotype. Male, Haines Falls, N.Y., June-August 1932, on lemon lily flowers, L. Lange (USNM type No. 67421).

Paratypes. 189 ♂♂, 193 ♀♀, same data as holotype (USNM), NYSM, W); 4 ♂♂, 87 ♀♀, Branch, Ulster Co., N.Y., June 15, 1956, on day lily, Smith & Wilcox (NYSM).

Hosts. Lemon lily, *Hemerocallis lilio-asphodelus* L. (*H. flava* L.); common orange day lily, *Hemerocallis fulva* (L.)

S. liriophilus has been found only in the Catskill Mountains. What appears to be the same species has been found on *Carpinus* in Albany county, as well as the Catskills. It seems odd that insects as restricted in host preference as these beetles seem to be would feed on such unrelated plants as *Hemerocallis* and *Carpinus*, but no morphological differences between the populations have been found.

S. chautauquus is very similar to *liriophilus* but differs in the more constricted and blunter aedeagus. In the other eastern species, the aedeagus is deflected or sinuate in lateral view.

SCOLOLYPERUS CHAUTAUQUUS, NEW SPECIES

Figure 117

Body and elytra entirely dark brown or black; upper surface with distinct green or blue luster. Clypeus and labrum paler, yellow or brown. Antennae and legs entirely yellow; posterior femora sometimes darkened. Vertex strongly alutaceous, impunctate. Ocular sulcus distinct, deep, with a few hairs near anterior portion. Supra-antennaria prominent. Coronal suture depressed near interocular sulcus. Tubercles with surface smooth, shiny, separated from orbit on each side by a broad depression. Antennae reach basal fourth of elytra. In both male and female, antennal segment 3 is equal to 2 in length, or segment 3 a little longer than 2 but not one and one-half times 2; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum as wide at base as at apex; sides moderately, evenly arcuate; width one and one-half times the length; without distinct depressions or rarely with a small depression on each side in basal third. Surface of pronotum smooth; shiny; may be faintly alutaceous; finely, sparsely punctate. Elytra half again as wide as pronotum at base; sides parallel; humeri prominent; surface moderately, evenly convex. Surface finely punctate; punctures separated by a distance three or four times their diameters; elytra strongly alutaceous, with a few scattered hairs on apical half.

Epipleuron moderately broad in basal half, becoming narrower at middle; narrow but distinct to apical angle. Last ventral abdominal segment of male truncate at apex, without apical lobe. Male with posterior tibiae straight; apical spurs on all tibiae; basitarsus normal on all legs; that of hind tarsus about as long as segments 2 and 3 together. Aedeagus with rounded, asymmetrical apex, nearly straight in lateral view, rather strongly narrowed at middle in dorsal view. Asymmetrical apex rather broad, evenly rounded.

Holotype. Male, Ashland Co., Ohio, V-19-51, E. L. Sleeper (W No. 425).

Paratypes. OHIO: 1 ♂, Hocking Co., V-10-36, J. N. Knull (OSU); 1 ♂, 1 ♀, Delaware Co., V-21, D. J. & J. N. Knull (OSU). ARKANSAS: 6 ♂♂, Mt. Magazine top, V-15-58, Evans & Flint (CORNELL). ALABAMA: Payne Lake, N. E. Hale Co., B. Valentine (W). NORTH CAROLINA: 2, Linville, VI-16-54, D. M. Weisman (W). NEW YORK: Clarksville, June 4, 1930, K. F. Chamberlain (NYSM). TENNESSEE: 2, Lookout Mt., June 7, 1947, J. G. Edwards (W).

S. chautauquus is generally smaller than other eastern species. The legs and antennae are almost always entirely yellow. The aedeagus, narrowed in the middle, is distinctive.

In the male from Delaware County, Ohio, the pronotum has a deep, round impression on each side just behind the middle.

SCELOLYPERUS HATCHI, NEW SPECIES

Figures 90, 113

Black or very dark brown; elytra black, may have extremely faint greenish luster; labrum, mandibles, tibiae, tarsi, apex of femora, and at least basal three segments of antennae yellow or pale brown. Vertex black, very finely punctate; surface smooth, shiny. Ocular sulcus deep, narrow. Supratentoria small indistinct. Coronal suture not impressed. Tubercles more or less rectangular, confluent with orbit on each side. Interantennal carina extends part way between

tubercles; sides with a row of three or four erect hairs. Antennae with third segment a little longer than second segment but not one and one-half times longer.

Pronotal width equal to 1.3 times length; width at base of pronotum a little greater than at apex, widest at apical third; sides moderately curved. Disc of pronotum flattened in basal half; surface smooth, shiny, finely punctate. Elytra evenly, moderately convex; humeri moderately prominent, without a distinct sulcus between them and disc of elytra. Punctuation moderate; punctures separated by a distance equal to two or three times their diameters. Surface between punctures very finely punctulate, not alutaceous.

Epipleura moderately broad at base, becoming gradually narrower; very narrow but distinct to apical angles. Male with tibiae straight; all tibiae with apical spurs; posterior tibia with broad, flat, apical lobe. Basal segment of each tarsus of male slightly enlarged; that of posterior tarsus about as long as the following two segments together. Last ventral abdominal segment of male without apical lobe. Aedeagus similar to that of *nigrocyaneus* and *nigrovirescens* but differing in not being narrowed at middle and in having a much more strongly produced apex.

Length 3.7 mm.

Holotype. Male, Boyer, Oregon, VII-14-39, K. Fender (CAS).

Paratypes. OREGON: 1 ♂, 8 ♀ ♀, same data as holotype (CAS, NYSM); 1 ♂, Marshfield, VI-14-1914 (CAS). WASHINGTON: 1 ♂, Skamania Co., Little Huckleberry Mt., J. Price (U. WASH.).

This species is very similar in size, color, and form to *S. nigrovirescens*, differing in the more strongly produced apex of the aedeagus and the presence of a broad, flat lobe on apex of each hind tibia of the male. The pronotum is a little narrower and not so flat as in *nigrocyaneus*, and the elytra are much more distinctly punctured and less alutaceous.

SCELOLYPERUS NIGROCYANEUS (LECONTE)

Figures 111, 112

Color dark brown or black; elytra may have very faint blue or green luster. Basal five segments of antennae, anterior tibiae, and apex of anterior and middle femora yellow. Vertex black, smooth, shining, impunctate. Ocular sulcus distinct but narrow and shallow. Supratentoria small, indistinct. Coronal suture not impressed. Surface of tubercles smooth, shiny. Tubercles separated from orbit by a broad, shallow, strigose depression. Interantennal carina not or

only slightly extended between tubercles. Antennae reach nearly to middle of elytra. Antennal segment 3 slightly longer than 2 but not one and one-half times longer; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum wider than long; width 1.4 times length. Pronotum a little wider at base than at apex, widest a little before middle. Sides moderately curved. Surface finely punctate, smooth, not alutaceous. Elytra moderately, evenly convex; humeri moderately prominent, without sulcus or depression between them and disc. Surface of elytra very finely punctate, very strongly alutaceous or finely rugulose. Epipleuron moderately broad at base, becoming gradually narrower; narrow but distinct at apical angle.

Male. Posterior tibiae very slightly curved; all tibiae with very small apical spurs. Posterior tibia with only a ridge representing an apical lobe. Tarsi normal. First segment of hind tarsus about as long as following two segments together. Last ventral abdominal segment without distinct apical lobe. Aedeagus similar to that of *nigrovirescens* in lateral view but a little more sinuate in apical half and straighter in basal half. Organ in dorsal view slightly, evenly tapering from base to apex. Apex produced, asymmetrical with right-angled tip far on the left side, pointed to side.

Length 3.3 to 3.5 mm.

Type. A male MCZ type No. 4347, from Veta Pass, Colorado, in the Leconte collection.

Other specimens examined. COLORADO: 2 ♂♂, Larimer Co. (U. ARK., W.); 3 ♂♂, 1 ♀, Denver, VI-1905 (CARNEGIE, NYSM); 4 ♂♂, 1 ♀, Denver (CARNEGIE); 1 ♂, 3 ♀♀, Denver, VII (CARNEGIE).

This species is very similar to *S. nigrovirescens*. The aedeagus is more strongly produced at the apex and more sinuate in lateral view. The lack of an apical lobe on the posterior tibiae of the male will distinguish it from *hatchi*.

SCELOLYPERUS NIGROVIRESCENS (FALL)

Figure 110

Body and elytra dark brown or black; clypeus, labrum, tibiae, tarsi, and basal segments of antennae yellow. Vertex with surface smooth, not alutaceous; impunctate or with a few fine punctures. Coronal suture not depressed. Ocular sulcus distinct. Tubercles with smooth, shiny surface; separated from orbit on each side by a broad, indistinct depression. Interantennal carina moderately swollen, not

extending between the tubercles, confluent with tubercles or separated from them by a very fine sulcus. Antennae reach basal third of elytra; antennal segment 3 equal to 2 in length; segment 4 longer than 3 but not so long as 2 and 3 together.

Pronotum narrower at apex than at base, widest at apical third. Sides nearly straight but divergent in basal half, strongly arcuate in apical half; pronotum wider than long, but width is not quite one and one-half times length. Surface of pronotum without distinct depressions or with a small depression on each side on basal third; smooth, not alutaceous; extremely finely punctate. Elytra half again as wide as pronotum at base; sides parallel; humeri prominent. Each elytron with length three times width. Surface of elytra moderately convex; without carinae. Elytral punctures very fine, separated by a distance three or four times their diameters; elytra strongly alutaceous between the punctures; with a few scattered hairs in apical half. Epipleuron moderately broad in basal half, becoming narrower at middle; narrow but distinct to apical angle.

Male with last ventral abdominal segment lacking apical lobe. Posterior tibia straight; with very small, thin, apical lamellate lobe. Apical spurs on all tibiae. Basitarsus of middle leg swollen, with pulvillus below. Basitarsus of hind leg longer than segment 2 but not quite so long as 2 and 3 together. Aedeagus with apex rounded, asymmetrical; slightly narrowed at apical third; strongly sinuate in lateral view.

Length 3 to 3.8 mm.

Type. The MCZ type, No. 25024, in the Fall collection is a female from Florissant, Colorado.

Host. Fall records the type series from the flowers of *Juncus*. This does not necessarily indicate that *Juncus* is the host since galerucine beetles may often be attracted to flowers of plants other than their normal host.

Other specimens examined. COLORADO: Raymond, 8-8-50, Dreisbach and Schwab (DREISBACH, W); Grant, 8-7-50, Dreisbach & Schwab (DREISBACH, W); Rio Branco Co., 8-6-50, Dreisbach & Schwab (W); Rocky Mt. N.P., July (W). MONTANA: Glacier Park, VIII-22, M. E. Smith (W); 4, Glacier Nat'l Pk., VII-13-30, Leach (CARNEGIE).

LYGISTUS, NEW GENUS

Elongate; sides of elytra parallel; slightly convex. Prothorax distinctly narrower than elytra. Eyes prominent. Head normal; interocular distance a little more than one-half width of head across

eyes. Interocular groove very deep, sinuate. Frontal tubercles strongly delimited, somewhat swollen, contiguous; interantennal carina short, not extending above antennal sockets.

Antennae of male reaching middle of elytra; second segment short, nearly spherical; third a little longer; fourth not quite so long as second and third together.

Pronotum a little wider than long, widest at apical third; surface without distinct impressions. Length of each elytron four times width; sides parallel. Epipleura of moderate width; visible nearly to apex.

Prosternum extending very narrowly between front coxae, not widened behind. Front coxal cavities open. Apex of fifth ventral abdominal segment broadly, deeply emarginate; depressed; weakly sclerotized; short lobe within the emargination densely pubescent. Front femora enlarged, larger than middle or hind femora. Apical spurs on middle and hind tibiae only in both male and female. Tarsal claws appendiculate.

Aedeagus without basal spurs; basal third nearly cylindrical; apical third produced, flattened, narrowed, and twisted. Orifice not covered by sclerotized plate. Internal sac covered with cornuti in apical two-thirds, the spines slightly larger at apex; flagellum weakly sclerotized, short, rounded.

Length 3.3 to 4.4 mm.

Type species: *Lygistus streptophallus*, new species.

The only species of this genus has dark head and elytra, the latter often with green luster; the prothorax usually dark brown in males and usually pale in females. There is some variation in both sexes in the pronotal coloration.

Lygistus is closely related to *Scelolyperus* but can be easily separated from that genus by the male characters: enlarged front femora, apex of abdomen, and aedeagus. Females are not so easy to differentiate, but the lack of spurs on the front tibia seems to be distinctive.

Lygistus, new genus

Type: *Lygistus streptophallus*, new species.
streptophallus, new species

Ariz.

LYGISTUS, STREPTOPHALLUS, NEW SPECIES

Figures 118, 119, 122, 123

Elongate; elytra parallel; pronotum a little more than half the width of elytra at base; eyes prominent; legs rather long; front

femora much broader than middle or hind femora in male. Color shiny dark brown or black; elytra usually with metallic green luster; pronotum pale in some specimens; antennae, tibiae, and tarsi pale brown. Elytra with a few, scattered, erect hairs.

Head shining, dark brown or black, usually with faint metallic green luster. Eyes prominent, sparsely pubescent. Vertex coarsely alutaceous in part, pubescent especially in and near interocular groove and behind eyes. Orbit coarsely strigose. Interantennal carina moderately developed with a row of hairs on each side.

Prothorax a little wider than long, widest at apical third. Sides evenly curved, sparsely pubescent. Front angles obtuse; hind angles acute. Basal margin sinuate, lacking marginal bead. Surface finely, closely punctate; glabrous. Median, basal area of elytra flattened; otherwise, elytra rather strongly convex. Scutellum same color as pronotum, finely alutaceous. Humeral sulcus deep; humerus prominent. Surface of elytra finely, closely punctate; with scattered, erect hairs.

Ventral surface of body dark brown or black, without metallic luster, shiny, pubescent. Sides of mesosternum densely pubescent. Abdomen shiny, finely strigose; sides moderately pubescent. First four segments equal in length along median line; segment 5 as long as segments 2 and 3 together, with very narrow median groove.

Femora dark brown or black, alutaceous, rather densely pubescent; tibiae and tarsi pale brown. First segment of hind tarsus shorter than second and third together. Tarsal claws appendiculate with long pointed lobes.

Basal third of aedeagus nearly cylindrical, slightly flattened ventrally; orifice at middle, lacking any sclerotized plate; apical third narrow, flattened, twisted, asymmetrical. Aedeagus without basal spurs. Internal sac covered with small spines which are largest near apex; without lobes; flagellum short, rounded, very slightly sclerotized.

Length 3.3 to 4.4 mm., width 1.3 to 1.7 mm.

Holotype. Male, Chiricahua Mts., Arizona, July-Sept., D. J. & J. N. Knull (OSU).

Paratypes. ARIZONA: 17 ♂♂, 28 ♀♀, same data as holotype (OSU, W, NYSM); 5 ♂♂, Nogales, St. Cruz Co., Sept. 4, 1906, Nunenmacher, Knab coll'n (USNM); 1 ♂, Santa Rita Mts., Aug. 16, '40, Knull (OSU); 4 ♂♂, 3 ♀♀, Pinery Cn., Chiricahua Mts., Aug. 17, 1949, Werner & Nutting, 5,500 ft. (U. ARIZ.); 2 ♂♂, 6 ♀♀, Rincon Mt., Sept. 16, 1937, Ball (U. ARIZ.); Globe, Sept. (MCZ-Fall); 4 ♂♂, Walker Can., 20-8-49, Callaghan, Lind, Say &

Kaiser, No. 69947, 49-17172, on side oats (*Bouteloua*), Gramma Grass (USNM); 14 ♂♂, Chiricahua Mts., 3.5 mi. S. W. Portal, 5,000 ft., 13. VIII-52, Leech & Green (CAS); 2 ♂♂, Pena Blanca 3,950 ft., Santa Cruz Co., August 26, 1959, J. G. Franclemont (CORNELL).

The male of this species is usually darker, with black or brown pronotum; only rarely is the pronotum pale. Nearly all female specimens examined have the pronotum reddish testaceous; and the front femora are normal, not swollen as in the male. Most of the specimens have rather evident green luster on the elytra; a few however, are more bronze than green.

The male of this species resembles *Scelolyperus torquatus* in form, differing in its more elongate pronotum, finer elytral punctation, enlarged front femora, lack of spurs on the front tibiae, and in the form of the aedeagus and last ventral abdominal segment. Darker specimens approach *Pseudoluperus lecontei* and *P. cyanellus* in color; but *lecontei* is a much larger, more robust species; and *cyanellus* has a much broader pronotum.

KEITHEATUS, NEW GENUS

Form elongate; sides of elytra parallel or slightly wider behind middle in female. Antennae reach to a little beyond the middle of elytra; segment 2 short; segment 3 is twice as long as 2; segment 4 is longer than 3 but not so long as 2 and 3 together. Apical spurs absent from all tibiae in male, present on all tibiae of female. Hind femora swollen, lacking an extensor apodeme but with a small, cylindrical flexor apodeme at the outer end of the flexor muscle. Basal segment of hind tarsus of male greatly dilated, concave beneath, almost as long as the rest of the segments together. Prosternum not produced between coxae; coxal cavities open. Apex of last abdominal segment of male with a short, broad lobe. Aedeagus symmetrical, without distinct basal spurs or sclerotized orificial plate; apex emarginate, broad, turned strongly upward. Length 3 to 4.5 mm. Head and pronotum pale; elytra dark, with faint greenish luster, with a broad longitudinal pale stripe which may extend in females nearly to the lateral and sutural margins.

The only known species has been found in the Big Bend region of Texas.

Keitheatus blakae (White) does not seem to be closely related to any other United States species. Its bicolored elytra are very distinctive. Though *blakae* resembles *Synetocephalus adenostomatus* (White) in color pattern, it differs in its broader prothorax, more

distinctly green luster, and the dilated posterior basitarsus of the male. It seems to be quite similar to *Luperodes histrio* Horn, from Baja California, but males of the latter species must be examined to make a satisfactory comparison. *Triarius vittipennis* (Horn) bears some resemblance to *blakeae*, especially in the female. There are two unusual characters which are known only in *blakeae* and *vittipennis*. These are (1) the form of the aedeagus with upturned apical third, and (2) the presence of a flexor apodeme in the swollen posterior femora.

Keitheatus, new genus

Type: *Scelolyperus blakeae* White, 1944, by monotypy.

blakeae (White)

Tex.

Scelolyperus blakeae White, 1944, Ent. News 55:178, fig.

KEITHEATUS BLAKEAE (WHITE)

Figures 121, 126

White described this species as follows: "Upper surface strongly shining, pronotum flavous to fulvous, elytra piceous and each with a broad, median flavous vitta.

"Head polished, not punctate, pale, darker above each eye and on the epicranium, frontal tubercles prominent, interocular space nearly twice the vertical width of the eye; clypeus and labrum with a few moderately long, pale setae; antennae reaching past middle of elytra, fuscous, basal segments less dark. Pronotum only slightly convex, two-thirds as long as wide, widest at apical third, surface polished, very finely, sparsely punctate, color flavous to rufous. Scutellum dark. Elytra a little more prominent; surface polished, very finely punctate (apparently impunctate); color piceous with a broad, median, flavous vitta extending from base to apex; the piceous areas with a greenish reflection in strong light; the flavous areas with a micro-granular appearance due to a fine but strong subcuticular, alutaceous structure; a few fine setae along the lateral and apical margins. Body beneath polished, pale, darker on episternal sclerites, sparsely covered with pale pubescence, more densely so at sides; legs fuscous, lighter at base, tibiae of male slightly arcuate and all without spurs, female with tibial spurs on all tibiae; basal segment of hind tarsus of males greatly dilated, concave beneath, almost as long as the other tarsal segments together. Length 3 to 4.5 mm.

"The sexes are dimorphic as usual in *Scelolyperus*. But, in addition to the usual differences between the sexes, such as the elytra more explanate in the female, tibiae slightly arcuate in the male,

antennae more elongate and filiform in male, and the different apical structure of the last ventral abdominal segment, there is apparently a color relationship. The females have a distinctly wider flavous vitta than the males. As a result of this feature, the females present quite a different facies to that of the male; and, in the extreme, they may have the dark margins almost absent. The male typically possesses flavous vittae equal in width to the piceous margins."

There is a small sclerotized strut in the posterior femora in this species. However, this is a flexor apodeme at the apex of the flexor muscle and not the same as the extensor apodeme described by Maulik as typical of the Alticinae.

Type. A male collected by B. E. White on *Condalia spathulata* A. Gray (Rhamnaceae), at Big Bend State Park, Brewster County, Texas, July 12 to 16, 1941. *K. blakeae* has also been collected in the Chisos Mts., Texas.

GENUS TRIARIUS JACOBY

Form elongate; sides parallel. Elytra wider than prothorax at base. Frontal tubercles prominent, not strongly swollen. Interantennal carina flat, short, not extending beyond the antennal insertions. Second and third antennal segments short; segment 3 a little longer than 2; segments 2 and 3 together as long as segment 4. Prothorax slightly wider than long, widest at apical third, without pronotal impressions. Prosternum not extending between coxae; coxal cavities may be open or closed. Last ventral abdominal segment with a broad, rectangular apical lobe in male. Apical spurs present on all tibiae of male and female. Tarsal claws may be bifid or appendiculate. Aedeagus symmetrical, without basal spurs, without sclerotized orificial plate.

Examination of types of three species of *Luperodes*, *flavoniger*, *melanolomatus*, and *nebrodes* shows that these have bifid tarsal claws and other characters of *Triarius*. *Triarius flavoniger* is an apparently distinct species known only by the two type specimens. *T. nebrodes* is identical with *T. lividus* (Leconte) and should be listed as a synonym of *lividus*. Mrs. Blake was the first to recognize *T. melanolomatus* as a distinct species, so *Triarius santarosarum* Wilcox becomes a synonym of that species.

A series of *Triarius lividus* in the Wenzel collection at the Ohio State University contains specimens which have entirely pale elytra as well as some with a dark sutural stripe. Dissection and examination of the male allotype of *T. suturalis* Martin shows it is very close to *lividus*. The color difference is striking. The sutural third of

each elytron of *suturalis* is dark with a distinct metallic green luster. The pattern is suggestive of female *Anomoea laticlavata* but does not reach the apex. There is little indication of green luster in other specimens of *Triarius*. However, since there seems to be no significant morphological difference between them, it seems better to list *suturalis* as a synonym of *lividus*.

Little is known of the biology of the species in this genus, although Henry Dietrich has collected large series of both *T. lividus* and *T. trivittatus* Horn on flowers of a yellow composite in Arizona.

Triarius Jacoby

Triarius Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):571.

Type: *Triarius mexicanus* Jacoby, 1887, by monotypy.

Horn, 1893, Trans. American Ent. Soc. 20:87.—Blake, 1942,

Proc. U.S. Nat. Mus. 92(3139):58-65 (part of *Luperodes*).

flavoniger (Blake)

Calif.

Luperodes flavoniger Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):64.

lividus (Leconte)

Tex., Ariz., Mexico

Phyllobrotica livida Leconte, 1884, Trans. American Ent. Soc. 12:28.

Triarius lividus (Leconte), Jacoby, 1892, Biol. Centr.-Amer., Coleop. 6(1):335.—Horn, 1893, Trans. American Ent. Soc. 20:89.

Triarius mexicanus Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):571.

Triarius suturalis Martin, 1928, Pan-Pacific Ent. 5:34. New synonymy.

Luperodes nebrodes Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):64, fig. New synonymy.

melanolomatus (Blake)

Ariz., Calif.

Luperodes melanolomatus Blake, 1942, Proc. U.S. Nat. Mus. 92(3139):63, fig.

Triarius santarosarum Wilcox, 1953, Ohio Jour. Sci. 53:51. New synonymy.

pini (Schaeffer)

Ariz.

Malacosoma pini Schaeffer, 1906, Brooklyn Inst. Arts Sci. Mus., Sci. Bull. 1, p. 248.

Exosoma pini (Schaeffer), Leng, 1920, Cat. Coleop. America, p. 298.

Exora pini (Schaeffer), Weise, 1924, Coleop. Cat., pars 78, p. 99.

GENUS PTELEON JACOBY

Body oval; sides of elytra parallel. Frontal tubercles well marked, with transverse sinuate groove between the eyes. Antennae short, extending little beyond base of prothorax; segments short, broader than long, triangular. Pronotum one-half wider than long, little narrowed at apex, evenly convex, without discal impressions. Elytra usually not modified, but in the male of the Mexican *P. pubescens* they are tumid along the suture at middle, pubescent and very strongly carinate at sides. Prosternum convex, separating the coxae; front coxal cavities open. All tibiae of both male and female with apical spurs. Claws appendiculate. Last ventral abdominal segment of male with a short, truncate, depressed, rectangular lobe at apex. Aedeagus symmetrical; base without spurs; orifice not covered by a sclerotized plate. Length 5 to 6 mm.

Yellow or reddish brown, suffused with dark brown, may be entirely black; two Mexican species are distinctly dark, dull blue.

Pteleon is quite close to *Exosoma*, a southern European and African genus, in morphology and general appearance. The species differ from *lusitanica* Fabricius, the type species of *Exosoma*, in the following characters: The third antennal segment is at least as long as the fourth; the aedeagus has a more attenuated tip and is not emarginate at apex; and the depressed area on the last abdominal segment of the male is restricted to the apical half, whereas in *Exosoma* the depression extends nearly to the base of the segment.

Pteleon Jacoby

Pteleon Jacoby, 1888, Biol. Centr.-Amer., Coleop. 6(1):603. Type:

Pteleon semicaeruleus Jacoby, 1888, by monotypy.

brevicornis (Jacoby) Utah, Tex., Mexico, Ariz.

Malacosoma brevicornis Jacoby, 1887, Biol. Centr.-Amer., Coleop. 6(1):582.

Malacosoma brevicorne Jacoby, Horn, 1893, Trans. American Ent. Soc. 20:123.

Exosoma brevicorne (Jacoby), Leng, 1920, Cat. Coleop. America, p. 298.

Exosoma brevicornis (Jacoby), Weise, 1921, Ark. f. Zool. 14(1):97.

Exora brevicornis (Jacoby), Weise, 1924, Coleop. Cat., pars 78, p. 99.—Wilcox, 1953, Ohio Jour. Sci. 53:54, fig.

californicus (Wilcox) Calif., Ariz.

Exora californica Wilcox, 1953, Ohio Jour. Sci. 53:52, fig.

Key to the species of *Pteleon* Jacoby

- Aedeagus with short, acute tip; head usually pale; 5-6 mm. long; Tex. to Ariz. to Mexico. *brevicornis* (Jacoby)
- Aedeagus with long slender tip, sides of tip parallel; head usually with vertex dark; punctures of pronotum more distinct; elytra more alutaceous than in *brevicornis*; 5 mm. long; Ariz. to Calif. (figures 131, 133) *californicus* (Wilcox)

GENUS *PHYLLOBROTICA* CHEVROLAT

Horn, 1893, described this genus as follows: "Head free, transversely grooved between the eyes. Eyes nearly round, prominent; labrum short, feebly emarginate; maxillary palpi not stout, the third and fourth joints obconical, the latter smaller and acute at tip. Antennae slender, longer and more slender in the female, first joint stout, second and third usually shorter, the third longer than the second, four to eleven nearly equal in length. Thorax transversely quadrate, sides nearly straight, disc usually with depressions; scutellum oval at tip. Elytra parallel, without lateral margin and without separate epipleurae; prosternum obliterated between coxae, the cavities open behind; metasternal parapleurae rather wide and parallel; ventral segments one to four equal in length, fifth much longer. Legs rather slender, tibiae without spurs; first joint of hind tarsus scarcely as long as the next two, claws appendiculate and divaricate."

Phyllobrotica Chevrolat

Phyllobrotica Chevrolat, 1837, in Dejean, Cat. Coleop., ed. 3, p. 405. Type: *Chrysomela quadrimaculata* Linnaeus, 1758.

Horn, 1893, Trans. American Ent. Soc. 20:98-102.—Blake, 1956, Proc. Ent. Soc. Washington 58:259-263.

sequoiensis Blake Calif.

Phyllobrotica sequoiensis Blake, 1956, Proc. Ent. Soc. Washington 58:260, fig.

leechi Blake Wash., Calif.

Phyllobrotica leechi Blake, 1956, Proc. Ent. Soc. Washington 58:260, fig.

viridipennis (Leconte) Calif.

Diabrotica viridipennis Leconte, 1859, Proc. Acad. Nat. Sci. Philadelphia, 1859, p. 81.

Phyllobrotica viridipennis (Leconte), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 207.—Horn, 1893, Trans. American Ent. Soc. 20:98, 101.—Horn, 1896, Proc. California Acad.

- Sci. (2)6:378.—Blake, 1956, Proc. Ent. Soc. Washington 58:259, fig.
- viridipennis mokelensis* Blake Calif.
Phyllobrotica viridipennis mokelensis Blake, 1956, Proc. Ent. Soc. Washington 58:262, fig.
- luperina* Leconte Calif.
Phyllobrotica luperina Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 207.—Horn, 1893, Trans. American Ent. Soc. 20:98,101.—Horn, 1896, Proc. California Acad. Sci. (2)6:378.—Blake, 1956, Proc. Ent. Soc. Washington 58:259, fig.
- nigripes* Horn Calif.
Phyllobrotica nigripes Horn, 1893, Trans. American Ent. Soc. 20:98,102.—Horn, 1896, Proc. California Acad. Sci. (2)6:378.—Blake, 1956, Proc. Ent. Soc. Washington 58:259, fig.
- lengi* Blatchley Ind., Miss.
Phyllobrotica lengi Blatchley, 1910, Coleop. Indiana, p. 1175.
- discoidea* (Fabricius) Conn., Ga., Ind., Tex.
Galleruca discoidea Fabricius, 1801, Syst. Eleuth. 1:485.
Phyllobrotica discoidea (Fabricius), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 207.—Horn, 1893, Trans. American Ent. Soc. 20:98-99.—Horn, 1896, Proc. California Acad. Sci. (2)6:378.
Galleruca circumdata Say, 1824, Jour. Acad. Nat. Sci. Philadelphia, vol. 3, p. 457.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 207 (synonym of *discoidea*).
- decorata* (Say) Maine, N.J., Colo.
Galleruca decorata Say, 1824, Jour. Acad. Nat. Sci. Philadelphia 3:459.
Phyllobrotica decorata (Say), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 206.—Horn, 1893, Trans. American Ent. Soc. 20:98.—Horn, 1896, Proc. California Acad. Sci. (2)6:378.—Linell, 1897, Proc. U.S. Nat. Mus. 20:483.
Galleruca Olivieri Kirby, 1837, Fauna Bor.-Americana 4:218.—Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 206 (synonym of *decorata*).
- costipennis* Horn Ga., Fla.
Phyllobrotica costipennis Horn, 1893, Trans. American Ent. Soc. 20:98-99.—Horn, 1896, Proc. California Acad. Sci. (2)6:387.
- limbata* (Fabricius) Conn., Mich., Tex.
Galleruca limbata Fabricius, 1801, Syst. Eleuth. 1:486.
Phyllobrotica limbata (Fabricius), Horn, 1893, Trans. American Ent. Soc. 20:98,100.—Horn, 1896, Proc. California Acad. Sci. (2)6:378.

- sororia Horn Tex.
Phyllobrotica sororia Horn, 1896, Proc. California Acad. Sci. (2)6:378.—Linell, 1898, Proc. U.S. Nat. Mus. 20:483.
- vittata Horn N.Y., Ga., Ind.
Phyllobrotica vittata Horn, 1893, Trans. American Ent. Soc. 20: 98,100.—Horn, 1896, Proc. California Acad. Sci. (2)6:378.—Schaeffer, 1919, Jour. New York Ent. Soc. 27:332.
- nigritarsis Linell Nebr., Tex.
Phyllobrotica nigritarsis Linell, 1898, Proc. U.S. Nat. Mus. 20: 483.
- antennata Schaeffer Tenn.
Phyllobrotica antennata Schaeffer, 1932, Canadian Ent. 64:237.
- stenidea Schaeffer N.Y., Ohio, D.C.
Phyllobrotica stenidea Schaeffer, 1932, Canadian Ent. 64:238.

Key to the species of *Phyllobrotica* Chevrolat

(Modified from Blake 1956 and Horn 1896)

- 1 Elytra entirely dark blue, green, or purple..... 2
 - Elytra partially yellow 7
- 2 Pronotum black, elytra blue or green..... 3
 - Pronotum yellow 5
- 3 Legs and antennae black; 5 mm. long; Calif.....*nigripes* Horn
 - Legs and antennae yellow 4
- 4 Elytra very shiny, not alutaceous, moderately punctate; median depression of the last ventral abdominal segment of male not delimited anteriorly by a transverse ridge; apex of aedeagus with an acute, strongly deflexed tip; 5.3-6.5 mm. long; Wash. to Calif.

leechi Blake

Elytra not as shiny, distinctly alutaceous, finely punctate; median depression of the last ventral abdominal segment of male delimited anteriorly by a more or less acute, transverse ridge; apex of aedeagus rounded, without acute, strongly deflexed tip; 5-6.5 mm. long; Calif.....*luperina* Leconte
- 5 Aedeagus spatulate, widened at apex, apex acutely pointed; elytra very inconspicuously and sparsely pubescent; spot on occiput usually large, frequently covering back of head; 5-6 mm. long; Calif. 6

Aedeagus little broader near apex than at middle, tip more evenly rounded, without acute tip; elytra covered with short fine pubescence; a small round spot

- on occiput; 4.8-5.8 mm. long; Calif. (figure 129)
sequoiensis Blake
- 6 Aedeagus widest before tip; apex rounded except for tip
viridipennis viridipennis (Leconte)
 Aedeagus widest very near tip; apex, except for tip,
 truncate *viridipennis mokelensis* Blake
- 7 Each elytron yellow with two, large, oval, dark spots.... 8
 Each elytron vittate or dark with pale suture and mar-
 gins 10
- 8 Head black, front pale; 5.5-7 mm. long; N.J. to Colo.; on
Lysimachia terrestris (Primulaceae).... *decorata* (Say)
 Head entirely yellow 9
- 9 Apical segments of antenna black; 6.5 mm. long; Nebr.
 to Tex. *nigritarsis* Linell
 Apical segments of antenna yellow; 7 mm. long; Tex.
sororia Horn
- 10 Each elytron with suture; margin and median discal stripe
 yellow; lateral dark stripe may be confined to apical
 half of elytra 11
 Elytra dark with only suture and margins yellow.... 13
- 11 Elytra yellow with subsutural stripe and submarginal
 stripe in apical half; head entirely yellow; 5.5-6 mm.
 long; Ind. to Miss. (figure 130)..... *lengi* Blatchley
 Elytral markings otherwise 12
- 12 Female with third antennal segment nearly as long as
 fourth; 4-5 mm. long; N.Y. to Tenn. to Ind. to Ga.
vittata Horn
 Female with third antennal segment distinctly shorter
 than fourth; 4 mm. long; N.Y. to Ohio to D.C.
stenidea Schaeffer
- 13 Elytra without prominent costae 14
 Each elytron with four prominent costae; aedeagus
 tapering from basal quarter; 6-7 mm. long; Fla. to
 Ga. *costipennis* Horn
- 14 Last ventral segment of male with a deep, nearly circular
 depression 15
 Last ventral abdominal segment of male with a shallow
 longitudinal depression; elytra very faintly costate;
 3.5-6.5 mm. long; Conn. to Ga. to Tex.
discoidea (Fabricius)
- 15 Antennae of male with basal segment strongly inflated,
 apical three segments yellow; 6 mm. long; Tenn.
antennata Schaeffer

Basal segment of male antenna not strongly inflated, terminal segments black; 5-6 mm. long; Conn. to Tex.; on *Scutellaria galericulata* (Labiatae)
limbata (Fabricius)

TRIBE SERMYLINI

This tribe is primarily an Oriental group. It is tentatively defined by the following combination of characters: Aedeagus symmetrical; orifice not covered by a sclerotized plate; basal foramen evenly rounded, margin heavily thickened and flaring. Last ventral abdominal segment of male with a short, evenly rounded, apical lobe. Prosternum nearly always raised, separating front coxae, frequently very broad in comparison with other Galerucinae. Frontal tubercles in many genera separated by the interantennal carina. Usually with apical spurs on only middle and posterior tibiae in both male and female. Tarsal claws usually appendiculate. Larvae are leaf feeders, with dorsal region of abdominal segments 1 through 7 subdivided into two transverse areas; epicranial suture well developed or long; one ocellus on each side of head.

Sermylassa is fairly typical of the tribe which contains most of the genera placed at one time or another in Bonesiites, Antiphites, Hylaspina, Sermylini, and Gallerucidini. *Agelastica* is atypical in many respects but appears to be most closely related to this group; consequently, it is tentatively included in the Sermylini.

GENUS SERMYLASSA REITTER

Body oval; prothorax with lateral marginal bead, slightly narrower than elytra. Male and female externally alike, except for last ventral abdominal segment. Eyes small; interocular distance a little more than half width of head across eyes. Interocular sulcus narrow, very shallow. Frontal tubercles moderately swollen, weakly delimited. Longitudinal clypeal carina broad, moderately swollen. Antennae moderately slender, reaching to middle of elytra; segment 2 short; 3 slightly longer than 2; segment 4 slightly longer than 2 and 3 together. Prothorax wider than long; width is about 1.7 times length. Surface of pronotum moderately convex, with a broad, deep, round depression on each side near middle. Elytra moderately, evenly convex, with a shallow transverse impression at basal fourth. Humeri prominent, separated from disc by a short, deep sulcus. Punctuation irregular, confused, or with a slight tendency to form rows. Surface glabrous, may have a few erect hairs on apical half. Epipleura wide at base, abruptly narrowed at basal third, distinct to sutural angle.

Prosternum moderately raised between coxae, narrowly separating them. Postcoxal lobe triangular, contiguous with epimera, thus closing anterior coxal cavities. Both male and female with apical spurs on middle and hind tibiae but not on front. Tarsal claws appendiculate. Last ventral abdominal segment of male with a short, evenly rounded, apical lobe; that of female evenly rounded. Aedeagus symmetrical; orifice near apex, not covered by a sclerotized plate; base of aedeagus without spurs; margin of basal foramen semicircular. Basal portion of aedeagus broader than rest of organ; internal sac apparently unarmed and unmodified.

Length 4.5 to 7 mm.

This genus contains two species, normally occurring in Europe and northern Asia to Japan. *S. halensis* has been reported from North America, but it is not known now whether the species has become established. If so, it can be easily recognized in the North American fauna by its closed coxal cavities, bright color of the elytra, and comparatively short first segment of the posterior tarsus.

The larva is a leaf feeder. It has an ocellus on each side, three dorsal transverse areas on each abdominal segment and distinct sclerites on the body. In these respects *Sermylassa* agrees with *Agelastica*. However, the larva of *Agelastica* is provided with supra-spiracular glands which are absent in *Sermylassa*.

Sermylassa Reitter

Sermyla Chapuis, 1875, Gen. Coleop. 11:224. Type: *Chrysomela halensis* Linnaeus, 1767, by original designation and monotypy.

Sermylassa Reitter, 1912, Fauna Germanica, 4:138. Type: *Chrysomela halensis* Linnaeus, 1767, by substitution of *Sermylassa* for *Sermyla* Chapuis, 1875, not Walker, 1854 (Lepidoptera). nor Adams, 1854 (Mollusca).

Adimonia: Stephens, 1834, Illust. British Ent., Mandib. 4:286.

Agelasa: Horn, 1893, Trans. American Ent. Soc. 20:60, 131.

Laboissiere, 1934, Ann. Soc. Ent. France 103:81.—Additional references are cited by Weise, 1924, Coleop. Cat., pars 78, pp. 139, 140.

halensis (Linnaeus) Europe, Siberia, ?North America

Chrysomela halensis Linnaeus, 1767, Syst. Nat., ed. 12, p. 589.

Agelasa halensis (Linnaeus), Horn, 1893, Trans. American Ent. Soc. 20:131.

Agelastica halensis (Linnaeus), Leconte, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 210.

Sermylassa halensis (Linnaeus), Reitter, 1912, Fauna Germanica 4:138.—Laboissiere, 1934, Ann. Soc. Ent. France 103:28, fig.—Additional references are cited by Weise, 1924, Coleop. Cat., pars 78, p. 139.

Larva. Böving, 1929, Proc. U.S. Nat. Mus. 75(2):35, fig.—Böving & Craighead, 1930, Ent. Americana, n. ser., vol. 11, no. 1, pl. 110, fig.—Paterson, 1931, Proc. Zool. Soc. London, 1931, p. 905, fig. (*Sermyla*).—Laboissiere, 1934, Ann. Soc. Ent. France, 103:23, fig.—Maulik, 1936, Fauna Brit. India, Coleop., Gal., p. 47.

SERMYLASSA HALENSIS LINNAEUS

Figures 132, 135, 136

Testaceous, except that vertex and elytra are bright metallic green, blue, or purple; antennae and tarsi are dark brown; scutellum is black. Vertex smooth, shiny; finely, sparsely punctate. Ocular sulcus broad, shallow. Supratentoria prominent. Coronal suture broadly, shallowly depressed near tubercles. Frontal tubercles rectangular with smooth, shiny, impunctate surface; separated from orbit by a broad, shallow depression; separated from each other by a very deep median sulcus. Longitudinal frontal carina with several long hairs below antennae, extending between antennae but not between tubercles. Transverse clypeal carina moderately developed, moderately declivous in front.

Pronotum widest at apical third. Lateral margins slightly arcuate. Posterior angles obtuse, not swollen; anterior angles rounded, strongly swollen. Surface of pronotum flattened at middle; central portion nearly impunctate; sides with moderate punctation; several coarse punctures behind or in impressions. Scutellum rounded at apex, broadly triangular. Elytral punctures moderate in size but variable; close, separated by a distance equal to about one-half to three-fourths their diameters. Lateral elytral margins moderately explanate. Legs robust but not modified. All basitarsi with entire ventral surface evenly, densely pubescent. Posterior basitarsus about as long as segments 2 and 3 together. Aedeagus broadly rounded at apex, with a very short deflected tip.

Length 5 to 7 mm.

Range. *Sermylassa halensis* (Linnaeus) occurs in Europe and Siberia. It has been recorded from Connecticut, Wisconsin, and Louisiana; but the North American records are doubtful. Leng, 1919, cited these questionable records and considered the species not to be North American.

This species is easily identified in the American fauna by its bright colors, closed coxal cavities, short posterior basitarsus, and deep pronotal impressions.

According to the records, the larvae feed on leaves of bedstraw, *Galium mollugo* and *G. verum* (Rubiaceae) in Europe.

GENUS AGELASTICA CHEVROLAT

Body broadly oval, strongly convex. Pronotum nearly as wide at base as elytra. Eyes small; interocular distance about one-half width of head across eyes. Interocular sulcus not strongly or distinctly impressed. Frontal tubercles distinct, moderately swollen; interantennal carina weakly swollen, may have a median longitudinal sulcus. Antennae moderately slender, reaching a little beyond basal third of elytra; segment 2 small; segment 3 a little longer; and segment 4 longer than 3 but not so long as 2 and 3 together. Pronotum nearly twice as wide as long; moderately, evenly convex. Elytra strongly, evenly convex; punctation confused; surface glabrous or with only a few, scattered, erect hairs. Epipleura wide at base, gradually narrowed; distinct nearly to sutural angle. Prosternum extending very narrowly between coxae; without postcoxal lobe; front coxal cavities widely open. Both male and female with apical spurs on all tibiae. Posterior basitarsus shorter than segments 2 and 3 together. Tarsal claws appendiculate. Last ventral abdominal segment of male with a slight sinuation on each side producing an extremely short, evenly arcuate apical lobe; that of female evenly rounded. Aedeagus symmetrical; orifice not covered by a sclerotized plate; base of aedeagus without spurs; internal sac with cornuti; flagellum sclerotized, complex.

Agelastica Chevrolat

Agelastica Chevrolat, 1837, in Dejean, Cat. Coleop., ed. 3, p. 405 (ed. 2, p. 381), Type: *Chrysomela alni* Linnaeus, 1758, designated by Chapuis, 1875, Gen. Coleop. 11:168.

Laboissiere, 1934, Ann. Soc. Ent. France 103:80.—Maulik, 1936, Fauna Brit. India, Coleop., Chrys., Gal., p. 326.—Additional references are cited by Weise, 1924, Coleop. Cat., pars 78, p. 129.

alni (Linnaeus) Europe to Japan, N.Y., N.J.

Chrysomela alni Linnaeus, 1758, Syst. Nat., ed. 10, p. 369.

Agelastica alni (Linnaeus), Dejean, 1837, Cat. Coleop., ed. 3, p. 405 (ed. 2, p. 381).—Schaeffer, 1919, Jour. New York Ent. Soc. 27:332.—Leng, 1919, Cat. Coleop. America, p. 298.—Laboissiere, 1934, Ann. Soc. Ent. France 103:80, fig.—Maulik, 1936, Fauna

Brit. India, Coleop., Chrys., Gal., p. 327.—Additional references are cited by Weise, 1924, Coleop. Cat., pars 78, p. 130.

Larva. Böving, 1929, Proc. U.S. Nat. Mus. 75(2):38, fig.—Böving and Craighead, 1930, Ent. Americana, n. ser., vol. 11, no. 1, plate 110 (fig.).—Laboissiere, 1934, Ann. Soc. Ent. France 103:22, fig.

AGELASTICA ALNI LINNAEUS

Figures 134, 137, 138

Entirely black; pronotum, elytra, and vertex with blue or violet luster. Male and female similar externally, except for last ventral abdominal segment. Interocular distance is five-eighths width of head across eyes. Vertex moderately, closely punctate. Ocular sulcus distinct, narrow, close to eye, coarsely punctate. Supratentoria moderate in size. Coronal sulcus may be distinct. Interocular sulcus indistinct, except for a broad, deep, median impression. Frontal tubercles with surface smooth; separated from orbit by several coarse punctures. Interantennal carina weakly swollen, with a thin median, longitudinal sulcus. Transverse clypeal carina moderately raised, strongly declivous in front. Antennal segment 2 small; segment 3 is 1.3 times length of 2; segment 4 is longer than 3 but not so long as 2 and 3 together.

Pronotal width nearly twice length, widest just anterior to basal angles, distinctly wider at base than at apex; sides moderately, evenly curved; angles obtuse, not produced. Surface with an extremely faint impression on each side at middle; finely, densely punctate. Posterior margin strongly curved. Scutellum triangular; apex acute. Humerus moderately rounded, without distinct sulcus separating it from disc. Elytral punctures fine, close, separated by a distance usually less than their diameters.

Last ventral abdominal segment of male with a small, very deep impression just before apex. Apex of aedeagus moderately narrowed; tip evenly rounded. Extreme basal portion of aedeagus very strongly sclerotized and pigmented. Inner sac with a basal ventral patch of cornuti; flagellum sclerotized, convex.

Length 6 to 7.5 mm.

Range. *Agelastica alni* (Linnaeus) occurs throughout Europe and eastward to Afghanistan and Japan. Leng, 1919, records it from New York and New Jersey, probably from the New York City area. There is also a specimen in the Fall collection (MCZ) from "Montreal, Quebec, 18-V-1915, J. I. Beaulne."

The very broadly oval form (length less than twice the width) and the color (entirely dark blue or violet) will readily identify this species. The larva and adult both feed on alder (*Alnus*) and hazel (*Corylus*) leaves.

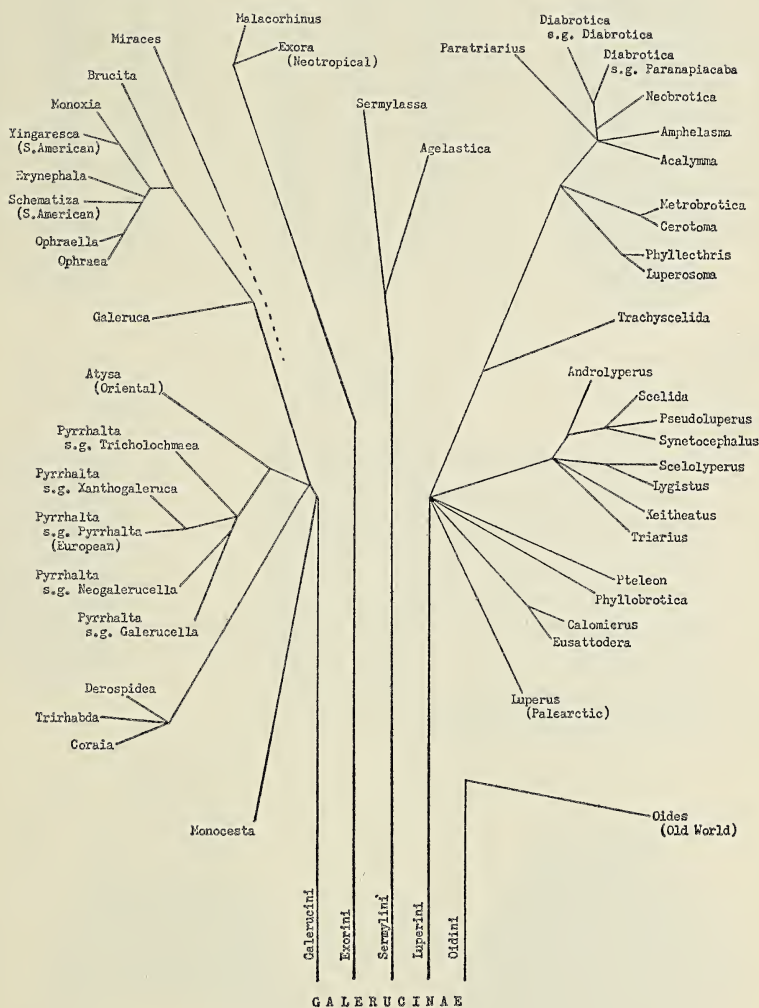


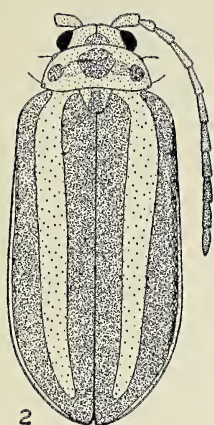
Plate I

FIGURE 1. Dendrogram illustrating degree of relationship between genera of Galerucinae, based on degree of similarity.

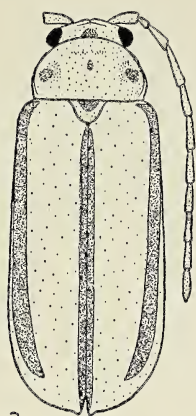
Plate II

FIGURES

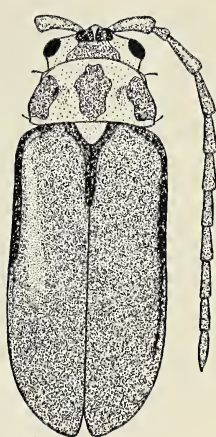
2. *Derospidea brevicollis* (Lec.).
3. *Trirhabda nitidicollis* Lec., ♂.
4. *Coraia subcyanescens* (Schaeffer), ♂.
5. *Miraces aeneipennis* Jac.
6. *Erynephala maritima* (Lec.).
7. *Erynephala maritima* (Lec.), ♀, front claws.
8. *Monoxia* sp., ♀.
9. *Monocesta coryli* (Say), ♂.
10. *Galeruca popenoei* Blake, ♀.



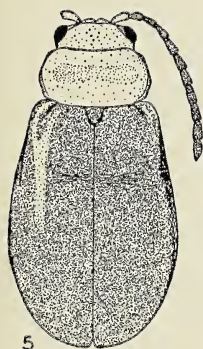
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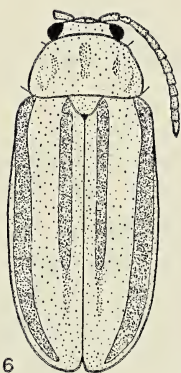
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4



5



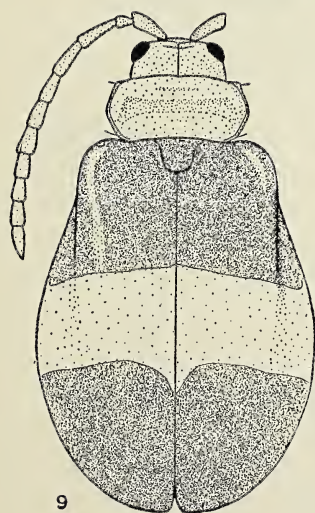
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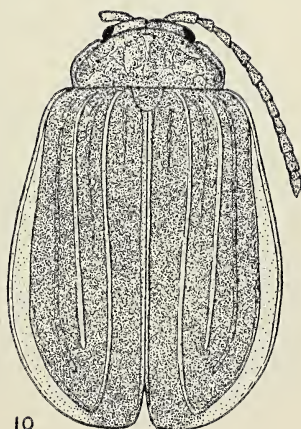
7



8



9



10

Plate III

In figures of the aedeagus, A is dorsal view, B is lateral.

FIGURES

11. *Ophraella notata* (Fab.).
12. *Ophraella sexvittata* (Lec.), aedeagus.
13. *Ophraella conferta* (Lec.), aedeagus.
14. *Galeruca rudis* Lec., aedeagus.
15. *Miraces aeneipennis* Jac., aedeagus.
16. *Pyrrhalta* (*Neogalerucella*) *quebecensis* (Brown), aedeagus.
17. *Brucita marmorata* (Jac.), aedeagus.
18. *Pyrrhalta* (*Galerucella*) *nymphaeae* (L.), aedeagus.
19. *Pyrrhalta* (*Neogalerucella*) *quebecensis* (Brown).
20. *Brucita marmorata* (Jac.).
21. *Pyrrhalta* (*Galerucella*) *nymphaeae* (L.)

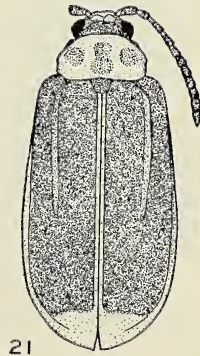
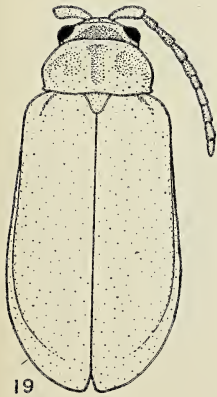
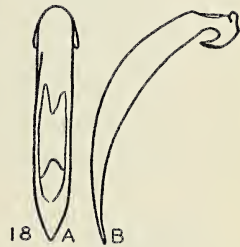
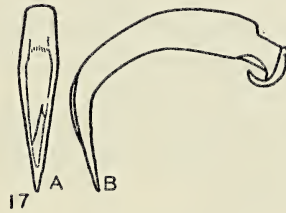
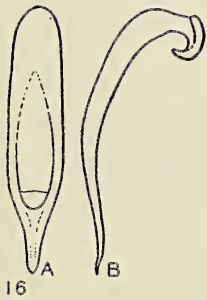
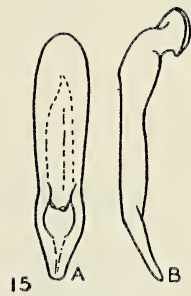
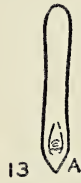
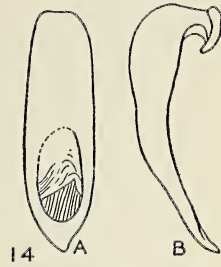
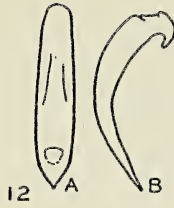


Plate IV

In figures of the aedeagus, A is dorsal view, B is lateral.

FIGURES

22. *Trirhabda canadensis* (Kirby), aedeagus.
23. *Erynephala maritima* (Lec.), aedeagus.
24. *Pyrrhalta* (*Tricholochmaea*) *tuberculata* (Say), aedeagus.
25. *Pyrrhalta* (*Xanthogaleruca*) *luteola* (Mull.), aedeagus.
26. *Pyrrhalta* (*Tricholochmaea*) *cavicollis* (Lec.), aedeagus.
27. *Ophraea rugosa* Jacoby, aedeagus.
28. *Pyrrhalta* (*Xanthogaleruca*) *luteola* (Mull.).
29. *Pyrrhalta* (*Tricholochmaea*) *cavicollis* (Lec.).
30. *Ophraea rugosa* Jacoby.

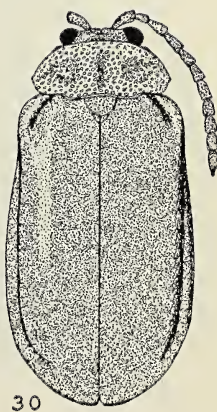
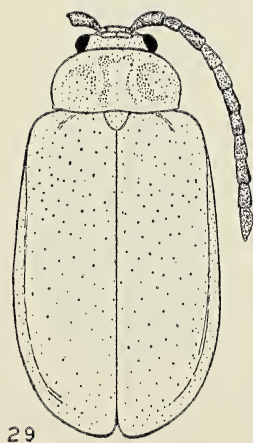
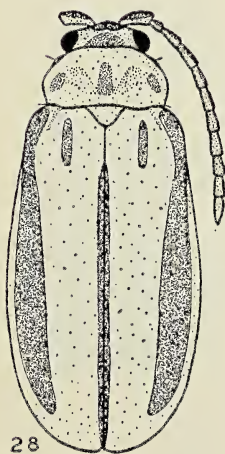
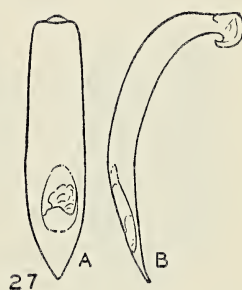
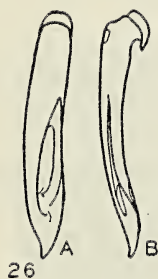
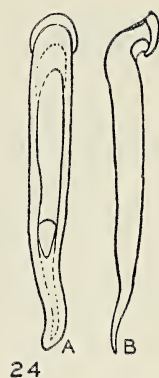
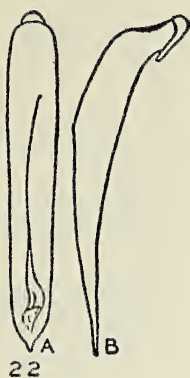
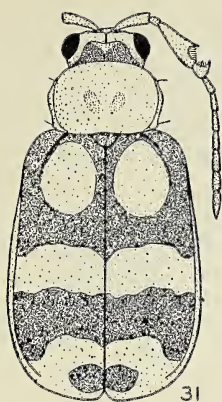


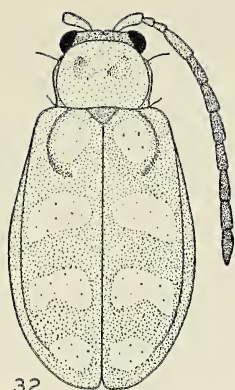
Plate V

FIGURES

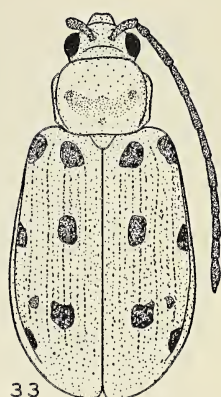
31. *Cerotoma ruficornis sexpunctata* (Horn), ♂.
32. *Diabrotica balteata* Lec., ♂.
33. *Neobrotica pluristictus* Fall, ♀.
34. *Diabrotica (Paranapiacaba) peregrina* (Jac.), ♂.
35. *Luperosoma subsulcatum* (Horn), ♂.
36. *Metrobrotica furcata* (Oliv.).
37. *Paratriarius dorsatus* (Say), ♂.
38. *Acalymma gouldi* Barber, ♀.
39. *Phyllecthris dorsalis* (Oliv.), ♂.



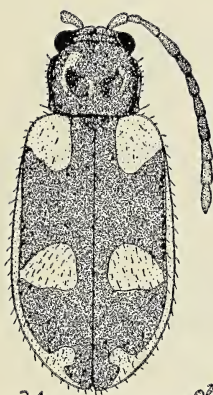
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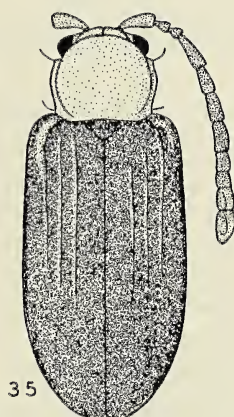
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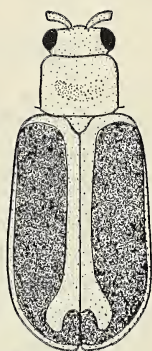
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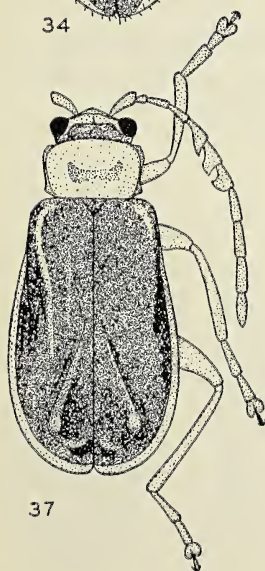
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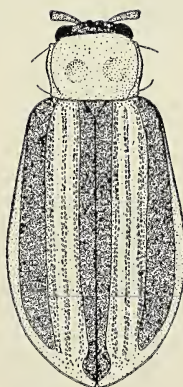
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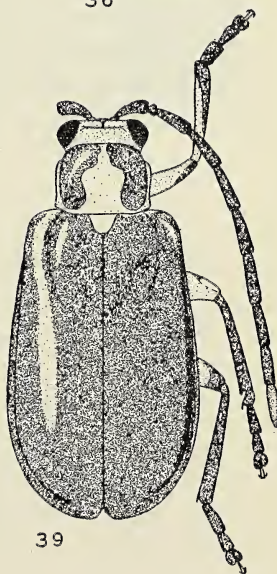
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37



38



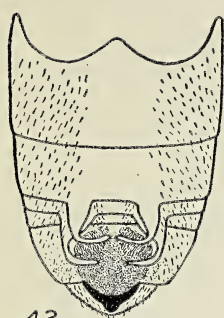
39

Plate VI

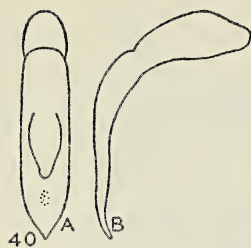
In figures of the aedeagus, A is dorsal view, B is lateral.

FIGURES

40. *Metrobrotica furcata* (Olivier), aedeagus.
41. *Metrobrotica furcata* (Olivier), aedeagus, ventral view.
42. *Androlyperus fulvus* Crotch, male abdomen, ventral view.
43. *Androlyperus fulvus* Crotch, aedeagus.
44. *Androlyperus fulvus* Crotch, ♂.
45. *Malacorhinus tripunctatus* (Jacoby), ♂.
46. *Malacorhinus tripunctatus* (Jacoby), aedeagus.
47. *Pseudoluperus decipiens* (Horn), ♂.
48. *Pseudoluperus longulus* (Lec.), ♂.
49. *Pseudoluperus longulus* (Lec.), aedeagus, Utah specimen.
50. *Pseudoluperus longulus* (Lec.), aedeagus, type of *P. bakeri*.
51. *Pseudoluperus decipiens* (Horn), aedeagus.



42

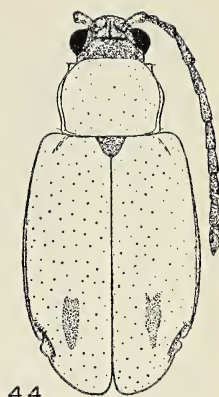


40 A

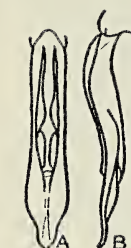
B



41

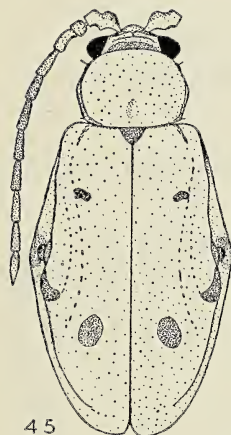


44



43 A

B



45

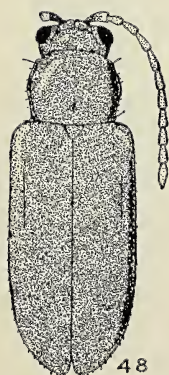


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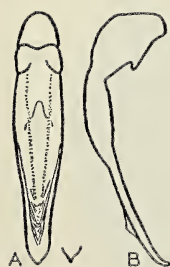
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47



48



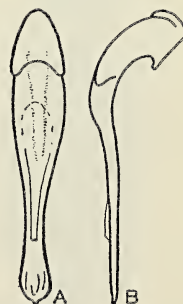
49 A

B



50 A

B

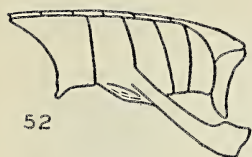


51 A

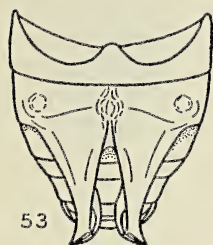
B

Plate VII**FIGURES**

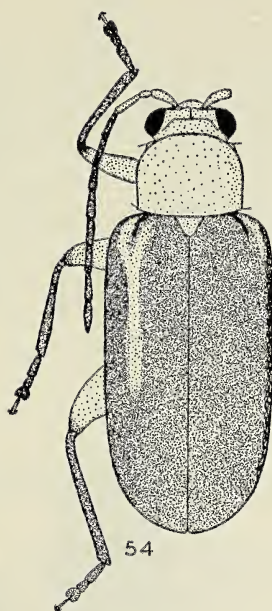
52. *Scelida flaviceps* (Horn), male, abdomen, lateral view.
53. *Scelida flaviceps* (Horn), male, abdomen, ventral view.
54. *Scelida flaviceps* (Horn).
55. *Pseudoluperus cyanellus* (Horn).
56. *Scelida flaviceps* (Horn), aedeagus, A is dorsal view, B is lateral view, C is ventral view.
57. *Trachyscelida bicolor* (Lec.), aedeagus, dorsal view.
58. *Scelida mimula*, new species, aedeagus, A is dorsal view, B is lateral view.
59. *Pseudoluperus lecontii* (Crotch).
60. *Trachyscelida bicolor* (Lec.).
61. *Pseudoluperus maculicollis* (Lec.).



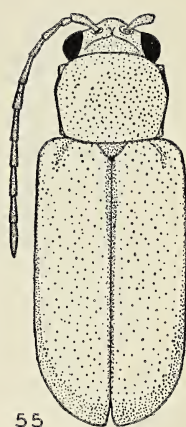
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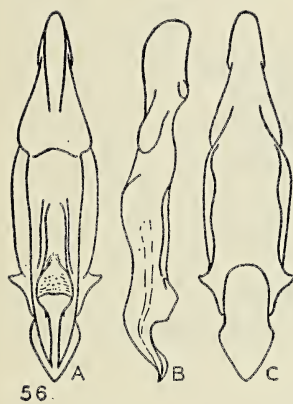
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54



55



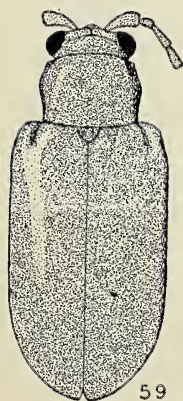
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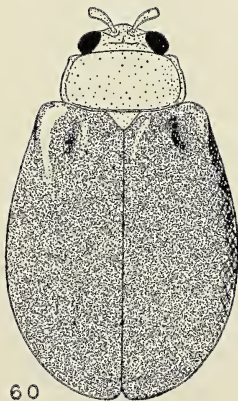
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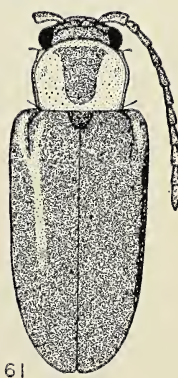
58



59



60



61

Plate VIII

In figures of the aedeagus, A is dorsal view, B is lateral.

FIGURES

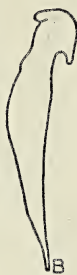
62. *Pseudoluperus fulgidus*, new species.
63. *Pseudoluperus fulgidus*, new species, aedeagus.
64. *Pseudoluperus lecontii* (Crotch), aedeagus.
65. *Pseudoluperus cyanellus* (Horn), aedeagus.
66. *Pseudoluperus wickhami* (Horn), aedeagus.
67. *Pseudoluperus wallacei*, new species.
68. *Pseudoluperus maculicollis* (Lec.), aedeagus.
69. *Pseudoluperus linus*, new species.
70. *Pseudoluperus linus*, new species, aedeagus.
71. *Pseudoluperus tuberculatus* (Blake), male abdomen, ventral view.
72. *Pseudoluperus tuberculatus* (Blake).



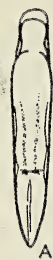
62



63



B



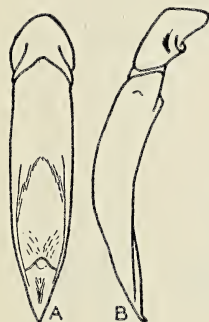
64



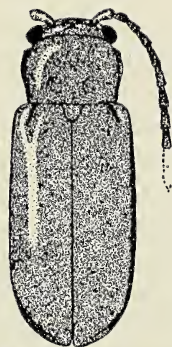
B



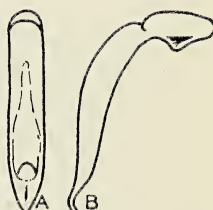
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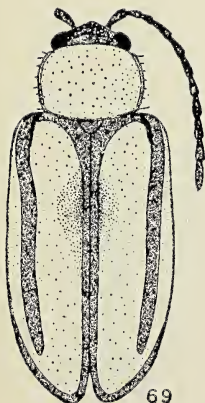
66



67



68



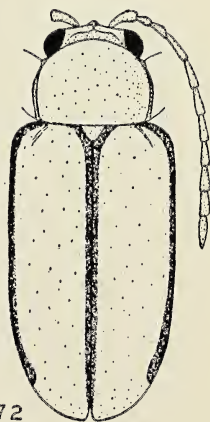
69



70



71



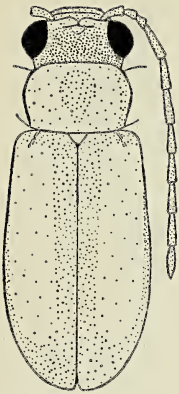
72

Plate IX

In figures of the aedeagus, A is dorsal view, B is lateral.

FIGURES

73. *Synetocephalus autumnalis* Fall.
74. *Synetocephalus autumnalis* Fall, aedeagus.
75. *Synetocephalus atricornis* (Fall), aedeagus.
76. *Synetocephalus bivittatus* (Lec.), aedeagus.
77. *Synetocephalus curvatus* (Fall), aedeagus.
78. *Synetocephalus crassicornis* (Fall), aedeagus.
79. *Synetocephalus vandykei* (Blake), aedeagus.
80. *Synetocephalus adenostomatus* (White).
81. *Synetocephalus adenostomatus* (White), aedeagus, B is lateral view with inner sac everted.
82. *Synetocephalus vandykei* (Blake).



73



74



75



76



77



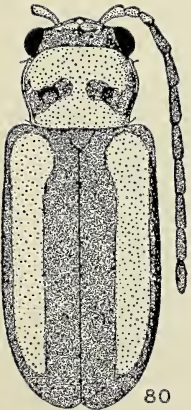
78



79



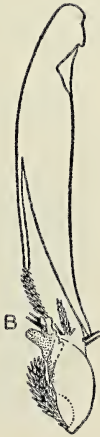
B



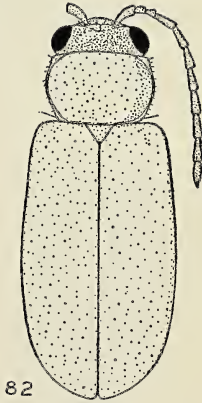
80



81



B

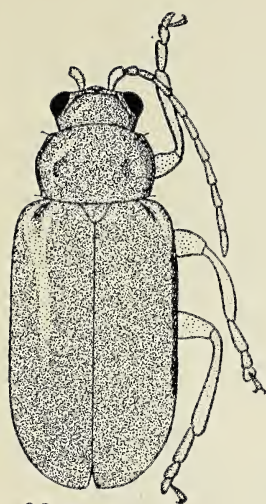


82

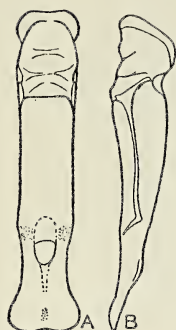
Plate X

FIGURES

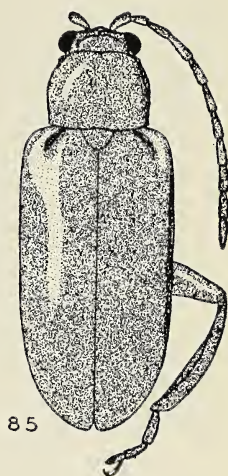
83. *Scelolyperus liriophilus*, new species.
84. *Scelolyperus curvipes*, new species, aedeagus, A is dorsal view, B, lateral view.
85. *Scelolyperus curvipes*, new species, male.
86. *Scelolyperus tejonicus* Crotch, posterior femur and tibia of male.
87. *Scelolyperus loripes* Horn, posterior femur and tibia of male.
88. *Scelolyperus megalurus*, new species, apical segments of male abdomen.
89. *Scelolyperus megalurus*, new species, posterior tibia and tarsus of male.
90. *Scelolyperus hatchi*, new species.
91. *Scelolyperus carinatus*, new species, female.
92. *Scelolyperus phoxus*, new species.



83



84



85



86



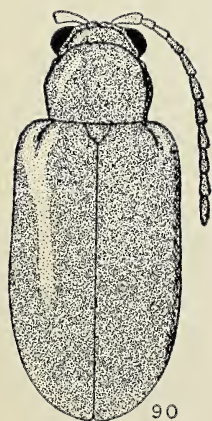
87



88



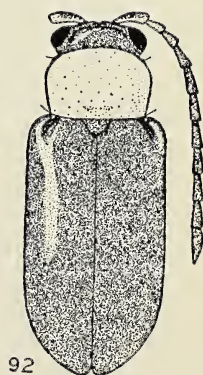
89



90



91



92

Plate XI

Aedeagi of *Scelolyperus*. A is dorsal view, B is lateral.

FIGURES

93. *S. transitus* (Horn).
94. *S. smaragdinus* (Lec.).
95. *S. flavicollis* (Lec.).
96. *S. torquatus* (Lec.).
97. *S. schwarzi* Horn.
98. *S. phoxus*, new species.
99. *S. laticeps* (Horn).
100. *S. phenacus*, new species.
101. *S. ratulus*, new species.
102. *S. loripes* Horn, ventral view of apex.
103. *S. ratulus*, new species, ventral view of apex.
104. *S. tejonicus* Crotch.
105. *S. megalurus*, new species.

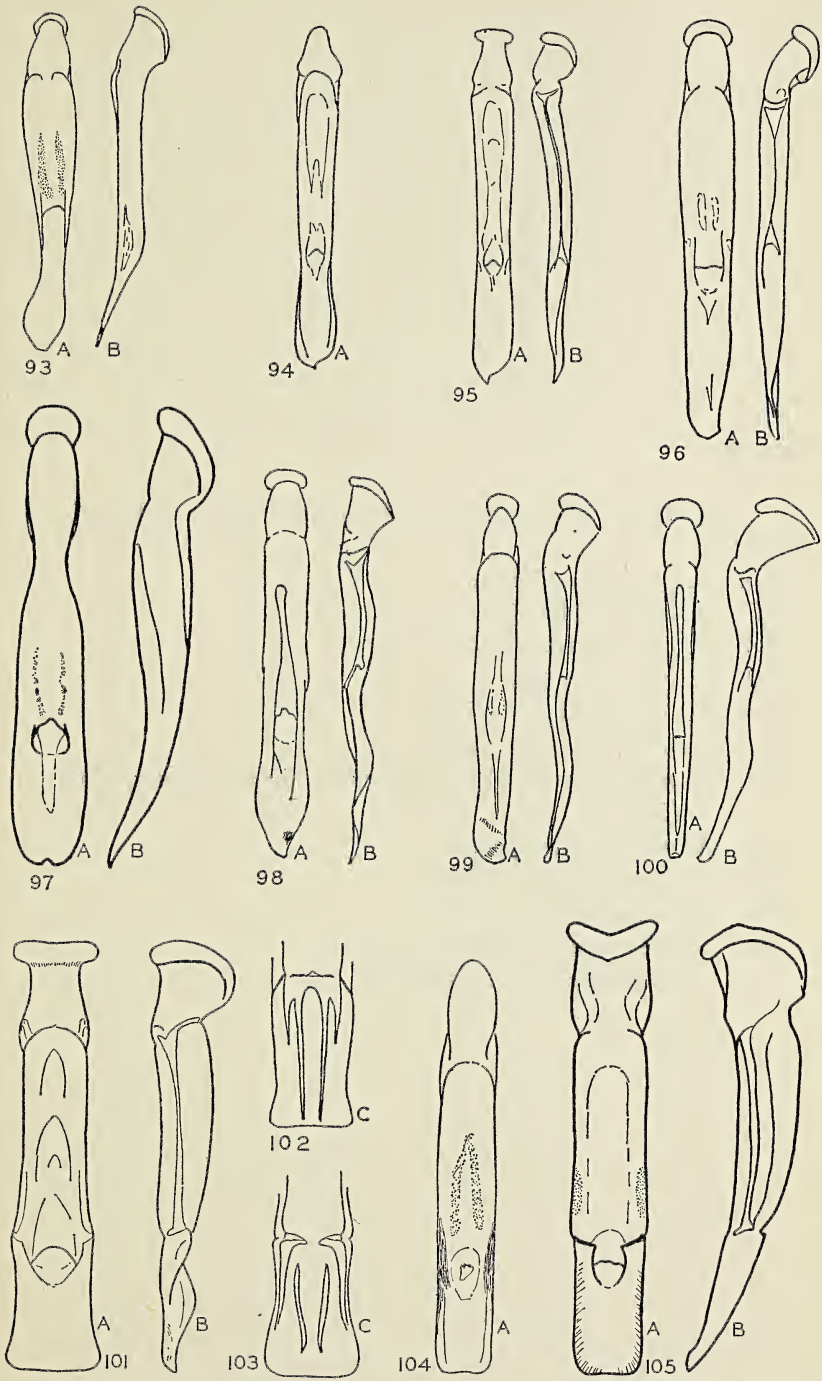


Plate XII

Aedeagi of *Scelolyperus*. A is dorsal view, B is lateral.

FIGURES

106. *S. cyanellus* (Lec.).
107. *S. varipes* (Lec.).
108. *S. graptoderoides* (Crotch).
109. *S. morrisoni* (Jac.).
110. *S. nigrovirescens* (Fall).
111. *S. nigrocyaneus* (Lec.).
112. *S. nigrocyaneus* (Lec.), specimen from Denver, Colo. (501).
113. *S. hatchi*, new species.
114. *S. bimarginatus* (Blake).
115. *S. meracus* (Say).
116. *S. liriophilus*, new species.
117. *S. chautauquus*, new species.

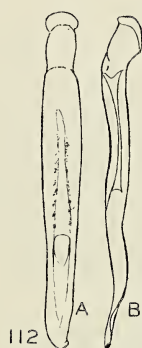
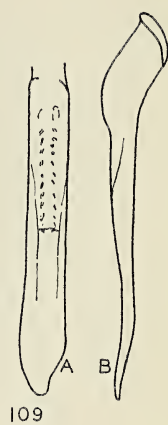


Plate XIII

In figures of the aedeagus, A is dorsal view, B is lateral.

FIGURES

118. *Lygistus streptophallus*, new species, ♂.
119. *Lygistus streptophallus*, new species, aedeagus.
120. *Triarius pini* (Schaeffer), aedeagus.
121. *Keitheatus blakeae* (White), aedeagus.
122. *Lygistus streptophallus*, new species, middle tarsal claws.
123. *Lygistus streptophallus*, new species, ♂ abdomen, ventral view.
124. *Triarius melanolomatus* (Blake), posterior tarsal claws.
125. *Triarius vittipennis* (Horn), aedeagus, C is ventral view.
126. *Keitheatus blakeae* (White).
127. *Triarius vittipennis* (Horn).
128. *Triarius lividus* (Lec.).

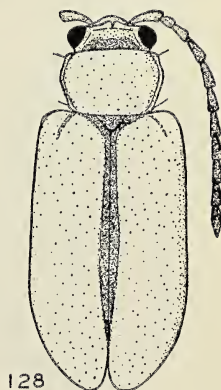
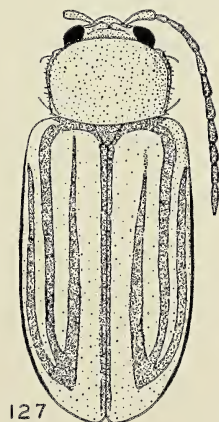
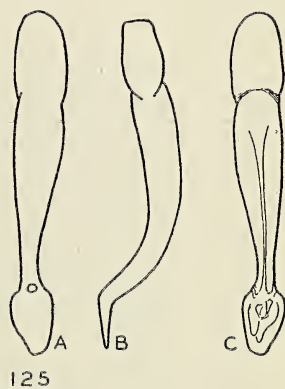
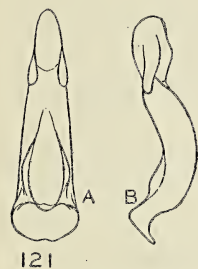
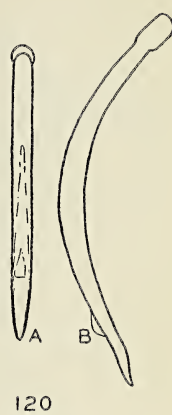
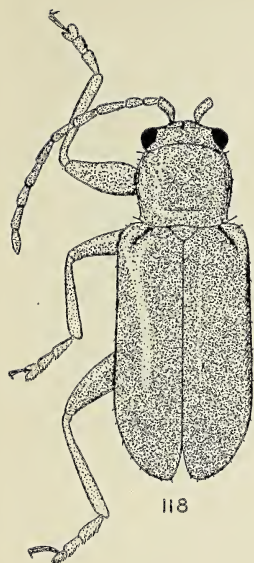
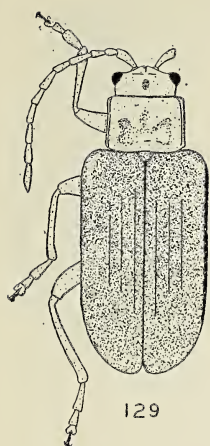


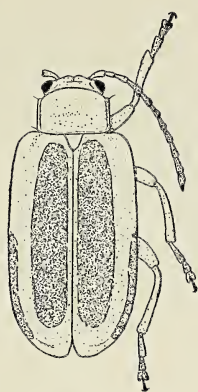
Plate XIV

FIGURES

129. *Phyllobrotica sequoiensis* Blake.
130. *Phyllobrotica lengi* Blatchley.
131. *Pteleon californicus* (Wilcox).
132. *Sermylassa halensis* (L.), aedeagus, A is dorsal view, B is lateral view, C is latero-ventral view.
133. *Pteleon californicus* (Wilcox), aedeagus, A is dorsal view, B is lateral view.
134. *Agelastica alni* (L.), aedeagus, A is dorsal view, B is lateral view.
135. *Sermylassa halensis* (L.).
136. *Sermylassa halensis* (L.), ventral view of abdomen, ♂.
137. *Agelastica alni* (L.), ventral view of abdomen, ♂.
138. *Agelastica alni* (L.).



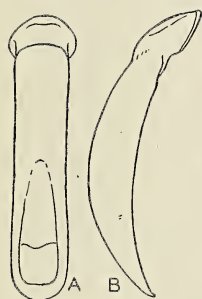
129



130



131



132



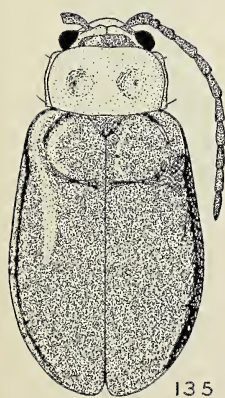
C



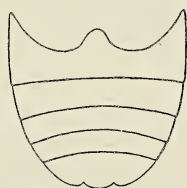
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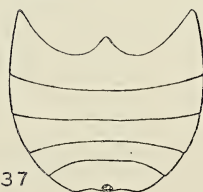
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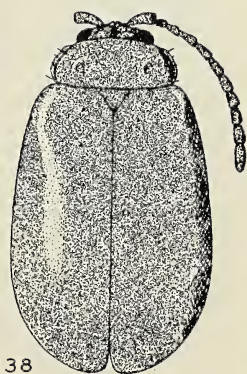
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136



137



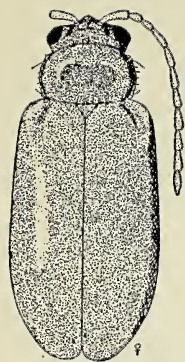
138

Plate XV

In figures of the aedeagus, A is dorsal view, B is lateral,
and C is ventral.

FIGURES

139. *Eusattodera pini* Schaeffer.
140. *Eusattodera pini* Schaeffer, aedeagus.
141. *Eusattodera delta* n. sp., aedeagus.
142. *Eusattodera pini* Schaeffer, ♂, head.
143. *Eusattodera delta* n. sp., ♂, head.
144. *Calomicrus morulus* (Lec.), type, MCZ no. 4345, aedeagus.
145. *Calomicrus rugosus* (Jac.), aedeagus.
146. *Eusattodera delta* n. sp., ♂, abdomen, ventral view.
147. *Calomicrus intermixtus* (Fall).
148. *Calomicrus intermixtus* (Fall), aedeagus.
149. *Calomicrus rugosus* (Jac.), ♂.



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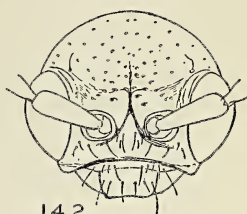
B



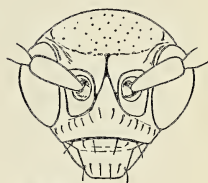
141



B



142



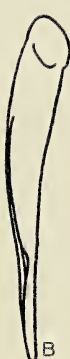
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144



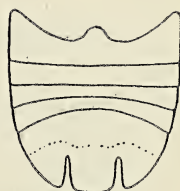
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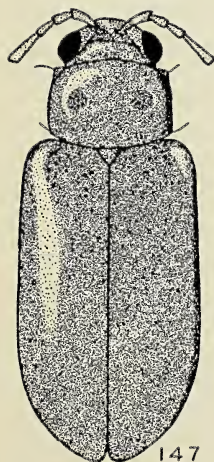
B



C



146



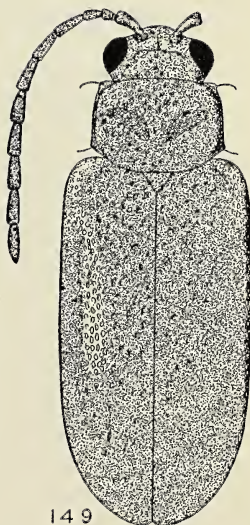
147



148



B



149

Plate XVI

Larva and pupa of *Scelolyperus meracus* (Say).

FIGURES

150. Larva, dorsal view of head.
151. Lateral view of larva.
152. Dorsal view of head and thoracic segments.
153. Dorsal view of second (part) and third abdominal segments.
154. Dorsal view of eighth and ninth abdominal segments.
155. Dorsal view of pupa.
156. Ventral view of pupa.

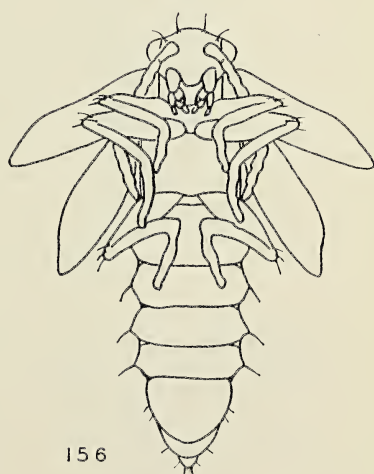
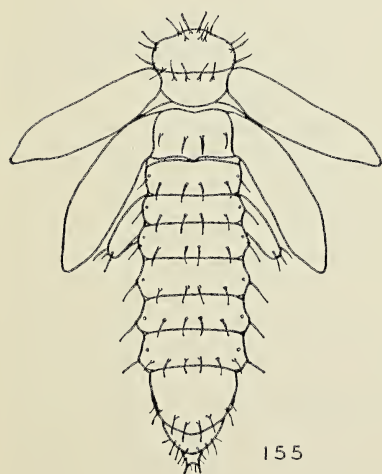
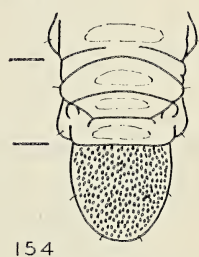
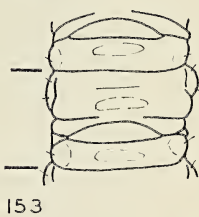
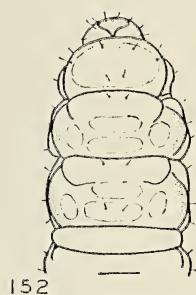
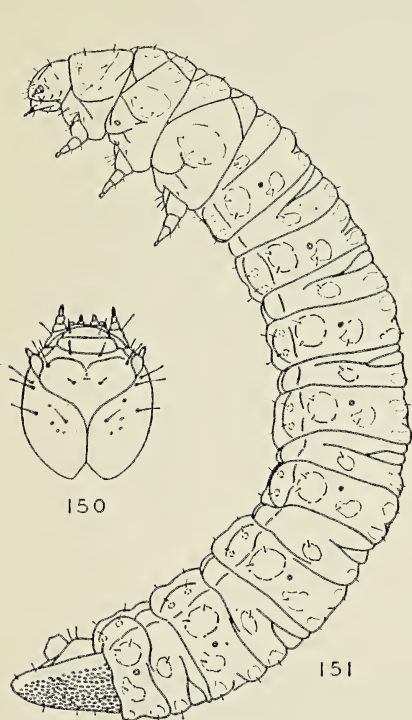
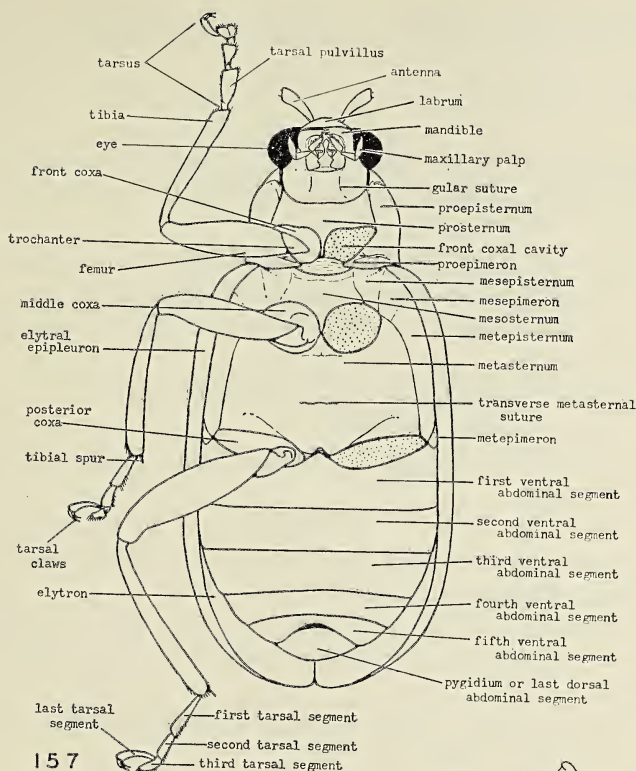


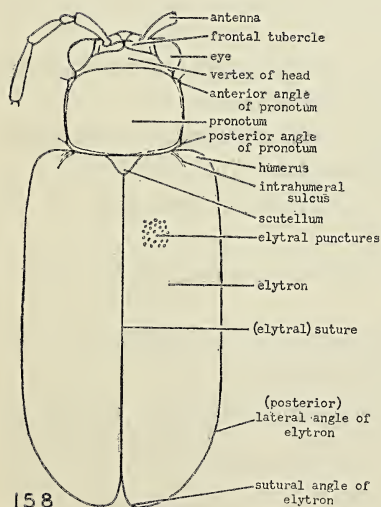
Plate XVII

FIGURES

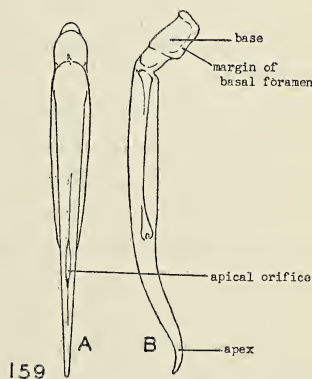
157. *Acalymma vittata* (Fab.), ventral view, parts labeled.
158. *Luperus flavipes* (L.), dorsal view, parts labeled.
159. *Scelolyperus carinatus* new species, aedeagus, A is dorsal view, B is lateral view, parts labeled.
160. *Scelolyperus smaragdinus* (Lec.), head, parts labeled.



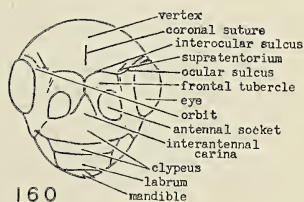
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Periodical Title Abbreviations

- Publications cited in this paper are abbreviated as follows:
- Agric. Exp. Sta., Bull. = Agricultural Experiment Station, Bulletin.
(Circ. = Circular)
- Ann. Mag. Nat. Hist. = Annals and Magazine of Natural History.
- Ann. Nat. Hist., London = Annals of Natural History. London.
- Ann. Soc. Ent. France = Annales de la Société entomologique de France. Paris.
- Arch. f. Nat. = Archiv für Naturgeschichte. Berlin.
- Ark. f. Zool. = Arkiv för Zoologi.
- Biol. Centr.-Amer., Coleop. = Biologia Centrali-Americana. Coleoptera. London.
- Boll. Lab. Zool. Portici = Bolletino del Laboratorio di zoologia generale e agraria della R. Scuola sup. (del R. Istituto—della Facoltà) d'agricoltura. Portici.
- Boston Jour. Nat. Hist. = Boston Journal of Natural History.
- Bull. Brooklyn Ent. Soc. = Bulletin of the Brooklyn Entomological Society.
- Bull. Mus. Hist. Nat., Paris = Bulletin du Muséum National d'Histoire Naturelle. Paris.
- Bull. Soc. Ent. Belgique = Bulletin de la Société entomologique de Belgique. Bruxelles.
- Bull. Soc. Imp. Nat. Moscou = Bulletin de la Société Impériale des Naturalistes de Moscou.
- Bull. U.S. G. & G. Surv. = Bulletin of the United States Geological and Geographical Survey of the Territories.
- Brooklyn Inst. Arts Sci. Mus., Sci. Bull. = Brooklyn Institute of Arts and Sciences Museum, Science Bulletin.
- Canadian Dept. Agric., Ent. Bull. = Canadian Department of Agriculture, Entomological Bulletin.
- Canadian Ent. = Canadian Entomologist (Entomological Society of Ontario). London, Ont.
- Cat. Coleop. = Catalogue des Coléoptères de la collection de M. le comte Dejean. Paris. 1837. By P. Dejean.
- Cat. Coleop. = Catalogus Coleopterorum hucusque descriptorum synonymicus et systematicus. Monachii. 1868-1876. By M. Gemminger & E. von Harold.

- Cat. Coleop. America = Catalogue of the Coleoptera of America, North of Mexico. Mount Vernon, N.Y. 1920. By C. W. Leng.
- Class. Coleop. N. Amer. = Classification of the Coleoptera of North America. Smithsonian Miscellaneous Collections No. 507. 1883. By J. L. Leconte and G. H. Horn.
- Coleop. Brasil = Coleopteros do Brasil. Sao Paulo Faculdade de Filosofia, Ciencias e Letras. Sao Paulo Universidade. 1953. By J. Guerin.
- Coleop. Cat. = Coleopterorum Catalogus auspiciis et auxilio W. Junk editus a S. Schenckling. Berlin and 's-Gravenhage. Pars 78, 1924, by J. Weise.
- Coleop. Indiana = An Illustrated Descriptive Catalogue of the Coleoptera or Beetles Known to Occur in Indiana. Indianapolis. 1910. By W. S. Blatchley.
- Complete Writings T. Say = The Complete Writings of Thomas Say on the Entomology of North America. Boston. 1883. By J. L. Leconte.
- Consid. Generales = Considérations générales sur l'ordre naturel des animaux composant les classes des crustacés, des arachnides, et des insectes; avec un tableau methodique de leurs genres, disposés en familles. Paris 1810. By P. A. Latreille.
- Dict. Univ. Hist. Nat. = Dictionnaire universel d'histoire Naturelle. Paris. 1841-1849. By C. D. d'Orbigny (entomological entries by L. A. A. Chevrolat and P. A. J. Duponchel).
- Encyc. Meth. = Encyclopédie méthodique. Histoire naturelle. Insectes. Paris. 1789-1812. By A. G. Olivier.
- Ent. Americana = Entomologica Americana. A journal of Entomology. Published by the Brooklyn Entomological Society.
- Ent. Arb. Mus. Frey = Entomologischen Arbeiten aus dem Museum G. Frey. Munchen.
- Ent. News = Entomological News. Academy of Natural Sciences, Philadelphia.
- Ent. = Entomologie, ou histoire naturelle des insectes, avec leurs caractères génériques et spécifiques, leur description, leur synonymie, et leur figure enluminée. Coléoptères. Paris. 1789-1808. By A. G. Olivier.
- Ent. Soc. Ontario, 43rd Ann. Rept. = Entomological Society of Ontario, Forty-third Annual Report.
- Ent. Syst. = Entomologia Systematica. Hafniae. 1792-1794. By J. C. Fabricius.
- Etud. Ent. = Études entomologiques. Helsingfors.
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100

GEOLOGIC MAP
OF THE
RICHFIELD SPRINGS
QUADRANGLE

by
L. V. RICKARD
1964

Mapping in 1953-1955

EXPLANATION

Dpm

Panther Mountain Formation
Dark bluish-gray shale, arenaceous shale, and flaggy, fine-grained argillaceous sandstone.

Dso

Solvay Sandstone
Upper part: fine-grained sandstone and arenaceous shale. Middle part: dark gray, thin, and unevenly bedded arenaceous shale. Lower part: very dark gray to black basile shale.

Dot

Osego Shale
Gray, irregularly bedded, lumpy siltstone overlying brownish-gray, fissile, soft shale.

Dch

Chittenango Shale
Black, basile shale with limestone septaria and calcareous concretions.

Duc

Cherry Valley Limestone and Union Springs Shale undifferentiated
Cherry Valley: black, arenaceous limestone, weathers rusty-orange. Union Springs: basile, black shale with calcareous concretions and thin limestone beds.

Don

Onondaga Limestone
Fine-grained, medium gray limestone with shaly partings and black chert. Basal member of massive, gray, coarse-grained, crinoidal limestone with white-weathering chert and coral reefs.

Dcc

Rickard Hill (Schoharie) Limestone, Carlisle Center Shale, Esopus Shale, and Oriskany Sandstone undifferentiated
Mainly buff-weathering, calcareous siltstone and shale assigned to the Carlisle Center Shale. Sporadic occurrence of arenaceous limestone, gray siliceous shale, and brown orthoquartzite assigned to remaining units.

Dk

Kalkberg Limestone
Medium grained, thin to medium bedded dark blue limestone with interbedded calcareous shale and black chert.

Ddb
Ddj

Deansboro (Coeymans) Limestone; Jamesville, Clark Reservation, and Elmwood (all Manlius) and Dayville (Coeymans) Limestones; Ravena (Coeymans) Limestone
Deansboro, Clark Reservation, and Elmwood: dark coarse-grained, crinoidal limestone with massive, irregular bedding. Jamesville: dark coarse-grained, crinoidal limestone, upper part of Ddb; fine to medium-grained, thin and evenly bedded limestone, stromatopora biostrome at top; Dayville, lower part of Ddb, coarse-grained, crinoidal limestone, some inter-bedded fine-grained limestone. Ravena: Dr, massive and irregularly bedded, coarse-grained crinoidal limestone.

Dct

Thacher (Manlius) Limestone, Chrysler (Rondout) Dolomite, and Cobleskill Limestone undifferentiated
Thacher: dark blue-black, fine-grained limestone with stromatopora biostrome. Chrysler: argillaceous shaly to thinly bedded dolomite and dolomitic limestone. Cobleskill: argillaceous mottled calcitic and dolomitic limestone.

Sty

Brayman Shale
Crumbly green shale overlying dark gray thin-bedded shale, argillaceous and dolomitic limestone.

Sv

Vernon Shale
Dark red and green crumbly shales lacking distinct bedding planes.

Swh

Herkimer Sandstone, Kirkland Hematite, and Willowvale Shale undifferentiated
Herkimer: coarse-grained medium to thick bedded light gray sandstone and quartz pebble conglomerate. Willowvale: platy green shale.

Sos

Sauquoit Formation, Otsego Sandstone, and Oneida Conglomerate undifferentiated
Sauquoit: platy green clay shale, quartz pebble conglomerate, and conglomeratic sandstone, brown siltstone and greenish-gray shale. Otsego: cross-bedded red coarse-grained sandstone. Oneida: hard quartz pebble conglomerate with black siliceous matrix, greenish-gray shale.

Of

Frankfort Shale
Greenish-gray and gray shales interbedded fine-grained cross-bedded quartzite sandstone.

Ou

Utica and Canajoharie-Dolgeville Shales undifferentiated
Utica: basile to massive black shale and argillite. Canajoharie-Dolgeville: basile black shale with interbedded black limestone.

CONTACTS

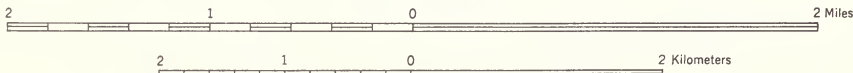
unconformable } location approximate
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concealed beneath thick glacial or alluvial deposits.



Base Map was prepared by assembly of
the 7½ minute quadrangles of the
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Scale 1:48,000



CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

LITHO. A. HOEN & CO.

GEOLOGIC MAP
OF THE
COOPERSTOWN
QUADRANGLE

by
D. H. ZENGER
1964
Mapping 1958



EXPLANATION

- UPPER DEVONIAN
- Do**
Oneonta Formation
Greenish-gray, thin-bedded, flappy and cross-bedded sandstone.
 - Dgi**
Gilboa Formation
Bluish-gray shale and argillaceous sandstone.
 - Dco**
Cooperstown Shale
Bluish, arenaceous shale and fine-grained gray and brown argillaceous sandstone.
 - Dpp**
Portland Point Limestone
Arenaceous calcarenite and calcareous shale.
- MIDDLE DEVONIAN
- Dpm**
Panther Mountain Formation
Dark bluish-gray shale, arenaceous shale, and flappy, fine-grained argillaceous sandstone.
 - Dso**
Solsville Sandstone
Upper part: fine-grained sandstone and arenaceous shale; Middle part: dark gray, thin and unevenly bedded arenaceous shale; Lower part: very dark gray to black fissile shale.
 - Dot**
Otsego Shale
Gray, irregularly bedded, lumpy siltstone overlying brownish-gray, fissile, soft shale.

CONTACTS

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